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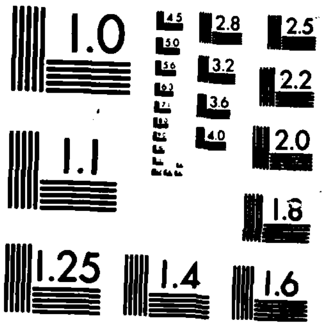
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Teacher's Guide
Volume II

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Prepared By:

SOFTECH, INC.
460 Totten Pond Road
Waltham, MA 02154

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Section 7
TASKS

INSTRUCTOR NOTES

THE OTHER PROGRAM UNITS WERE PACKAGES (WHICH PHYSICALLY GROUP RESOURCES) AND SUBPROGRAMS (WHICH ARE EXECUTABLE). TASKS ARE A SECOND FORM OF EXECUTABLE PROGRAM UNIT.

TASKS

- ADA PROGRAM UNIT THAT PROVIDES PARALLEL THREADS OF CONTROL
- CONCURRENCY REAL WITH MULTIPROCESSORS
- CONCURRENCY APPARENT WITH SINGLE PROCESSOR
- MECHANISM FOR SYNCHRONIZATION AND DATA TRANSMISSION IS CALLED "RENDEZVOUS"
- RUNTIME SYSTEM HANDLES TASK SCHEDULING

INSTRUCTOR NOTES

TASKS ARE AN IMPORTANT DESIGN ISSUE. POINT OUT THAT SYSTEM DESIGN SHOULD BE APPROACHED WITH THE IDEA OF USING TASKS WHERE APPROPRIATE. OPTIMIZATION TECHNIQUES EXIST TO REDUCE THE OVERHEAD OF TASK SYNCHRONIZATION. OPTIMIZATION SHOULD NOT BE DONE PRIOR TO IDENTIFYING BOTTLENECKS IN THE CODE USING BENCHMARKS AND OTHER ANALYSIS.

TASKS

CAN BE USED FOR

- CONCURRENT ACTIONS
- CONTROLLING RESOURCES
- INTERRUPTS
- BUFFERS

INSTRUCTOR NOTES

(TASKS MUST BE INSIDE OTHER PROGRAM UNITS)

POINT OUT THE DIFFERENCE BETWEEN TASK SPECIFICATIONS AND OTHER SPECIFICATIONS: TASKS HAVE ENTRY DECLARATIONS ONLY.

TASK SYNTAX

```
task Task_Name is

   entry Entry_Name [(Formal_Parameters)];
end [Task_Name];
```

SPECIFICATION

- Visible Part
- Defines entry point(s) to the task

```
task body Task_Name is

begin
   accept Entry_Name [(Formal_Parameters)] do
      -- statement(s);
   end Entry_Name;

end [Task_Name];
```

BODY

- Hidden
- Additional Declarations
- Implements the task

  -- statements
  -- accept entries

- TASKS ARE DECLARED IN SUBPROGRAMS OR PACKAGES

INSTRUCTOR NOTES

TASKS -- RENDEZVOUS

WHEN EITHER A CALLED TASK OR ITS CALLER ARRIVE AT A RENDEZVOUS POINT, THE ONE THAT ARRIVES FIRST WAITS FOR THE OTHER ONE

DURING THE RENDEZVOUS (THE EXECUTION OF THE STATEMENTS IN THE ACCEPT) THE CALLER IS SUSPENDED. THE CALLER RESUMES EXECUTION AFTER THE RENDEZVOUS IS COMPLETED.

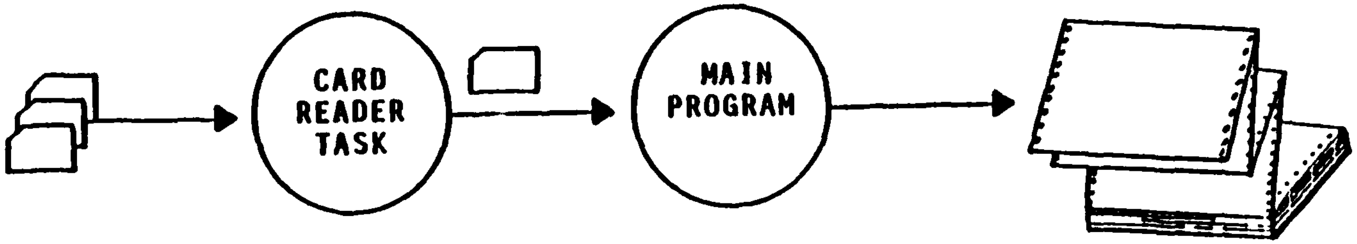
INSTRUCTOR NOTES

THE CODE FOR THIS EXAMPLE APPEARS ON THE NEXT SLIDE AND IS TO BE DISCUSSED IN DETAIL.

MAKE SURE THE STATEMENT OF THE PROBLEM IS WELL UNDERSTOOD BY THE CLASS.

TASKS TO OVERLAP I/O

COPY CARD IMAGES FROM "STANDARD INPUT" TO "STANDARD OUTPUT" -- READING IS IMPLEMENTED AS A TASK EXECUTING CONCURRENTLY WITH THE MAIN PROGRAM



INSTRUCTOR NOTES

WALKTHROUGH THE EXAMPLE IN DETAIL.

BASIC SYNCHRONIZATION

MAIN PROGRAM

```
with Text_IO;
procedure Main is
      type Card is String (1 .. 80);
      C : Card;

      task Card_Reader is
            entry Get (C: out Card);
      end Card_Reader;

      task body Card_Reader is separate;

begin -- Main
      loop
            Card_Reader.Get (C);
            Text_IO.Put (C);
      end loop;

end Main;
```

SPECIFICATION

BODY

ACCEPT

ENTRY CALL

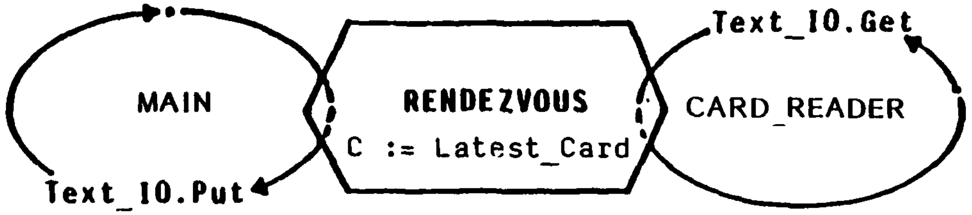
CARD READER TASK

```
separate (Main)

task body Card_Reader is
      Latest_Card : Card;

begin -- Card_Reader
      loop
            Text_IO.Get (Latest_Card);
            accept Get (C : out Card) do
                  C := Latest_Card;
            end Get;
      end loop;

end Card_Reader;
```



INSTRUCTOR NOTES

AN EXAMPLE OF A SELECT STATEMENT WITH GUARDS OCCURS IN SEVERAL PAGES IN THE RESOURCE CONTROLLER EXAMPLE.

OTHER SYNCHRONIZATION ALTERNATIVES

ADA PROVIDES ADDITIONAL SYNCHRONIZATION FOR THE FOLLOWING SITUATIONS:

CALLED TASK

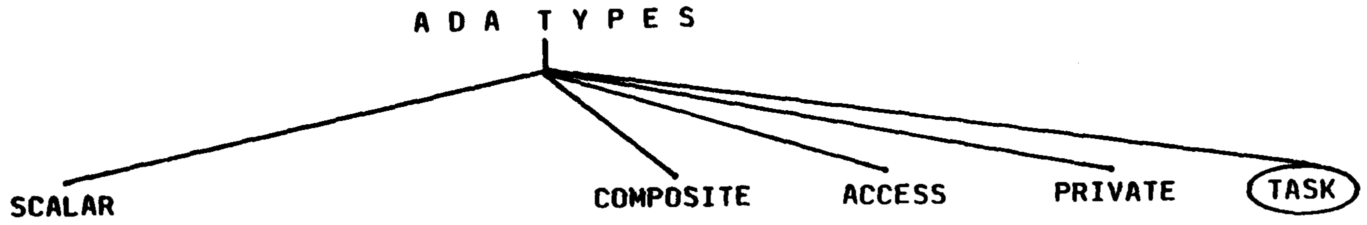
- ACCEPTS ONE OF SEVERAL ENTRY CALLS

CALLING TASK

- SUSPENDS EXECUTION FOR SOME SPECIFIED TIME
- CALLER NEEDS TO INITIATE RENDEZVOUS WITHIN A GIVEN TIME
- CALLER MUST RENDEZVOUS IMMEDIATELY

INSTRUCTOR NOTES

TASK TYPES



ADA TYPES

SCALAR

COMPOSITE

ACCESS

PRIVATE

TASK

INSTRUCTOR NOTES

RELATE BACK TO THE DISCUSSION OF TYPES WHERE A TYPE IS A DEFINITION. TO GET A VARIABLE YOU DECLARED AN OBJECT. SAME THING HERE. WHAT WE GET IS A PROCESS.

TASK TYPES -- BASIC IDEA

- ALLOWS THE USER TO CREATE A TASK TEMPLATE

- TASK OBJECTS CAN THEN BE CREATED FROM THIS TEMPLATE - OBJECTS ARE LIKE ANY OTHER TASK

INSTRUCTOR NOTES

TASK TYPES -- BASIC IDEA

EXAMPLE:

```
task type Simple_Channel is

        entry Send (M : in Message);
        entry Receive (M : out Message);

end Simple_Channel;

task body Simple_Channel is

        --  LIKE A TASK DEFINITION

end Simple_Channel;
```

TO USE:

```
Channel_1, Channel_2 : Simple_Channel;
.
.
.
Channel_1.Receive (Msg);  --  GET A MESSAGE
Channel_2.Send (Msg);     --  AND SEND ON OTHER CHANNEL
```

INSTRUCTOR NOTES

USE TASKS WHEN LOGICALLY SEVERAL OPERATIONS CAN BE OCCURRING INDEPENDENTLY OF EACH OTHER.

THE ALTERNATIVE WOULD BE TO HAVE CHECKS FOR THE TIME EVERY FEW STATEMENTS WITHIN EDITOR (I.E., A CLUTTERED MESS). THIS SOLUTION LETS THE EDITOR BE AN EDITOR AND THE TICKER, A TICKER. IN THIS WAY THE ABSTRACTION OF THE PROBLEM IS PRESERVED.

POINT OUT THAT Calendar IS A PREDEFINED PACKAGE WHICH PROVIDES DATE AND TIME UTILITIES.

TASKS AS CONCURRENT ACTIONS

PROBLEM: AN INTERACTIVE PROGRAM (E.G., AN EDITOR) MUST DISPLAY THE TIME OF DAY IN A CORNER OF THE SCREEN AT ALL TIMES.

```
with Calendar;
procedure Editor is

   procedure Display_Time (T : in Calendar.Time) is separate;

   task Ticker;

   task body Ticker is
   begin -- Ticker
      loop
         Display_Time (Calendar.Clock);
         delay 0.1;
      end loop;
   end Ticker;

begin -- Editor
   ...
end Editor;
```

INSTRUCTOR NOTES

IN SYSTEM STARTUPS COULD BE PERFORMING BACKGROUND DIAGNOSTICS (E.G. WHAT RESOURCE DEVICES ARE CURRENTLY AVAILABLE) WHILE THE MAN MACHINE INTERFACES ARE PERFORMED (E.G. PROMPTING THE OPERATOR FOR THE DATE, TIME).

TASKS AS CONCURRENT ACTIONS

OTHER REAL-TIME SYSTEM EXAMPLES:

- MAN-MACHINE INTERFACES
- BACKGROUND DIAGNOSTICS

INSTRUCTOR NOTES

ADA EXAMPLE SPANS 2 SLIDES.

THIS EXAMPLE SHOWS A FAMILY OF ENTRIES INDEXED BY URGENCY IN THE TASK Request_Function.

WHY IS THIS NECESSARY? WHEN TWO OR MORE TASKS COMPETE FOR A RESOURCE (E.G., THE PRINTER, OR A COMMON TABLE), SOME FORM OF ARBITRATION IS NEEDED. OTHERWISE THE PRINTOUTS WILL BE INTERMIXED OR A TASK MIGHT MODIFY A SHARED TABLE WHILE ANOTHER TASK IS READING IT.

TASKS USED TO CONTROL RESOURCES

```
package Resources is

   type Resource_Type is (Reader, Printer, Terminal_1, Terminal_2);
   type Urgency Is (High, Medium, Low);

   procedure Some_Actions (Resource : in Resource_Type);

   task Resource_Controller is

      entry Request_Function (Urgency) (Resource : Resource_Type);

   end Resource_Controller;

end Resources;
```

INSTRUCTOR NOTES

A LOOK AT THE TASK BODY. NOTE THE RENDEZVOUS POINTS AND THE GUARDS.

THE EXAMPLE IS OVERSIMPLIFIED; OTHER PARAMETERS WILL BE NEEDED IN PRACTICE, SUCH AS THE TEST TO BE PRINTED.

TASK CONTROLLING RESOURCES (Continued)

```
package body Resources is

   procedure Some_Actions (Resource : in Resource_Type) is separate;
   task body Resource_Controller is
   begin -- Resource_Controller
      loop
         select
            accept Request_Function (Urgency => High)(Resource : Resource_Type) do
               Some_Actions (Resource);
            end Request_Function (High);
         or
            when Request_Function (High)'Count =  0 =>
               accept Request_Function (Urgency => Medium)(Resource : Resource_Type) do
                  Some_Actions (Resource);
               end Request_Function (Medium);
         or
            when Request_Function (High)'Count = 0 and
               Request_Function (Medium)'Count = 0 =>
               accept Request_Function (Urgency => Low)(Resource: Resource_Type) do
                  Some_Actions (Resource);
               end Request_Function (Low);
         end select;
      end loop;
   end Resource_Controller;

end Resources;
```

INSTRUCTOR NOTES

WHEN Character_Reader, Character_Ready IS CALLED, CONTROL BRANCHES TO THE HARDWARE ADDRESS $A1_{16}$.

TASKS AS INTERRUPT HANDLERS

```
task Character_Reader is

   entry Character_Ready (C : in Character);
   for Character_Ready use at 16#00A1#;          -- PHYSICAL ADDRESS OF THE
                                                 -- INTERRUPT ROUTINE

end Character_Reader;


with Buffer;          -- A LIBRARY PACKAGE WHICH SUPPORTS QUEUE OPERATIONS
task body Character_Reader is

begin

   loop
      accept Character_Ready (C : in Character) do
         Buffer.Add (C);
      end Character_Ready;
   end loop;

end Character_Reader;
```

INSTRUCTOR NOTES

IN I/O EXAMPLE, CAN BE ADDING TO OR DELETING FROM A_File SIMULTANEOUSLY, THUS THERE IS NO WAY TO ENSURE THE ACCURACY OF DATA IN A_File.

WHILE TASKS CAN BE USED TO CODE A CYCLIC EXECUTIVE, THEY ARE BETTER USED TO DEVELOP A MAINTAINABLE, DATA-DRIVEN DESIGN. AS AN EXAMPLE, CONSIDER A TARGET TRACKING SYSTEM WITH THESE ALTERNATIVES: A TASK PER TRACK (THERE IS AN UPPER LIMIT OF HOW MANY TRACKS A SYSTEM CAN FOLLOW) VERSUS ONE TASK PER RADAR SECTOR. TASK PER TRACK IS MORE ELEGANT AND A BETTER ABSTRACT MODEL.

SOME POTENTIAL PITFALLS - TASKS

- STATE OF DEADLOCK WHERE TWO TASKS EACH ENDLESSLY WAIT FOR THE OTHER

- UNCONTROLLED ACCESS TO DATA

```
procedure IO is

   task Card_Reader;
   task Printer;

   task body Card_Reader is
   begin
      Get_Char (A_Char);          -- A_Char, A_File PREVIOUSLY DECLARED
      Put_Char (A_File);
   end Card_Reader;

   task body Printer is
   begin
      Get_File (A_File);
      Put_Char (A_File);
   end Printer;

begin -- IO
   null;
end IO;
```

- GETTING STAFF TO USE TASKS INSTEAD OF CODING SEQUENTIALLY

INSTRUCTOR NOTES

Section 8
GENERICS

INSTRUCTOR NOTES

GENERIC UNITS - MOTIVATION

LET'S SUPPOSE AN ADA SYSTEM NEEDS A STACK OF INTEGERS:

```
package Int_Stack is

   type Stack_Type is private;

   procedure Push (X : in Integer);
   function Pop return Integer;

private

   Stack_Size : constant Integer := 100;

   type Stack_Type is array (1 .. Stack_Size) of Integer;

end Int_Stack;
```

AN ADA SYSTEM MAY ALSO NEED A STACK FOR REALS OR ARRAYS OR ENUMERATION TYPES OF VARYING STACK SIZE. THE ALGORITHM REMAINS THE SAME. RATHER THAN CODE A STACK PACKAGE FOR EACH TYPE OR SIZE, WE CAN CODE ONE GENERIC PACKAGE.

INSTRUCTOR NOTES

STRESS THAT GENERICS ARE A DESIGN ISSUE. DESIGNERS MUST LOOK FOR POTENTIAL REUSES OF CODE.

GENERIC PROGRAM UNITS - BASIC IDEA

- PROVIDE EFFECTIVE REUSE OF COMMON CODE
- ARE PARAMETERIZED TEMPLATES OF A PROGRAM UNIT
- ENHANCE READABILITY
- BUILD LIBRARIES
- ARE TEMPLATES LIKE TYPES, TO CREATE AN 'OBJECT' AN INSTANCE OF EXECUTABLE CODE IS PRODUCED

INSTRUCTOR NOTES

SOME MAJOR USES OF GENERICS ARE ...

GENERICS

CAN BE USED TO

- WRITE ONCE MODULES WHOSE ALGORITHMS DON'T DIFFER
- PASS TYPES OR SUBPROGRAMS AS PARAMETERS TO PROGRAM UNITS
- DETAIL DESIGN OPTIONS WHILE DEFERRING DESIGN DECISIONS

INSTRUCTOR NOTES

GENERIC UNITS - BASIC FORM

TEMPLATE:

```
generic

        -- GENERIC PARAMETERS TO PASS
        -- THESE ARE THE PARTS THAT DIFFER

Generic_Package_Or_Subprogram_Specification;

Generic_Package_Or_Subprogram_Body is

        -- THIS IS THE COMMON ALGORITHM

end;
```

INSTRUCTOR NOTES

REMIND STUDENT THAT THEY DON'T GET THIS CODE. IT'S JUST LIKE A TEMPLATE OR A MACRO.

GENERIC PARAMETERS SAY: I WILL PASS YOU THE TYPE OF THE Stack_Item TO PUT ON THE STACK AND ITS EXACT SIZE.

GENERIC SPECIFICATION SAYS: YOU WILL BE ABLE TO PUSH AND POP Stack_Items OF THE STACK.

USE THIS SLIDE WITH NEXT SLIDE.

GENERIC UNIT - EXAMPLE

GENERIC PARAMETERS

```
generic

   Stack_Size : Natural;
   type Stack_Item is private;
```

GENERIC PROGRAM UNIT SPECIFICATION

```
package Stack is

   type Stack_Type is private;
   procedure Push (X : in Stack_Item; On_To : in out Stack_Type);
   function Pop (Off_Of : Stack_Type) return Stack_Item;

private
   type Stack_Type is array (1 .. Stack_Size) of Stack_Item;

end Stack;
```

GENERIC PROGRAM UNIT BODY

```
package body Stack is

   ...

   procedure Push (X : in Stack_Item; On_To : in out Stack_Type) is

   ...

   end Push;

   function Pop (Off_Of : Stack_Type) return Stack_Item is

   ...

   end Pop;

end Stack;
```

INSTRUCTOR NOTES

RELATE THE GENERIC SPECIFICATION FROM THE PREVIOUS SLIDE TO THE EXAMPLES.

GENERIC UNITS - USE

A GENERIC UNIT DESCRIBES A TEMPLATE. TO CREATE EXECUTABLE CODE FOR A SPECIFIC USE, WE DECLARE AN INSTANCE OF THE TEMPLATE CALLED AN INSTANTIATION.

SYNTAX:

```
package Package_Name is new Generic_Package_Name (Parameter_List);
```

```
procedure Procedure_Name is new Generic_Procedure_Name (Parameter_List);

function Function_Name is new Generic_Function_Name (Parameter_List);
```

EXAMPLE:

```
type Real is digits 5;
package Int_Stack is new Stack (100, Integer);
package Real_Stack is new Stack (50, Real);

subtype Small_Integer_Type is Integer range 1 .. 15;
package Small_Int_Stack is new Stack (100, Small_Integer_Type);
```

INSTRUCTOR NOTES

GENERIC FORMAL PARAMETERS ARE WHAT WE CAN USE TO VARY THE PACKAGE OR SUBPROGRAM.

WE WILL LOOK AT EXAMPLES OF EACH AS WE LOOK AT EXAMPLES OF GENERIC USES.

GENERIC UNITS - FORMAL PARAMETERS

GENERIC PARAMETERS CAN BE

- GENERIC FORMAL OBJECTS
- GENERIC SUBPROGRAMS
- GENERIC TYPES

ACTUAL PARAMETERS IN A GENERIC INSTANTIATION ARE MATCHED TO THE FORMAL PARAMETERS OF THE GENERIC DEFINITION.

INSTRUCTOR NOTES

FOR LIMITED PRIVATE WE CAN PASS ANY TYPE BECAUSE YOU CAN ONLY DO THE OPERATIONS SPECIFIED IN THE GENERIC SPECIFICATION.

GENERIC FORMAL PARAMETERS - TYPES

- SIX WAYS OF EXPRESSING A GENERIC FORMAL TYPE

```
            FORMAL                              ACTUAL

   type Item is limited private;      -- ANY TYPE
   type Item is private;              -- ANY TYPE FOR WHICH EQUALITY
                                      -- AND INEQUALITY ARE DEFINED

   type Item is ( <>);                -- ANY DISCRETE TYPE
   type Item is range  <>;            -- ANY INTEGER TYPE
   type Item is delta <>;             -- ANY FIXED POINT TYPE
   type Item is digits <>;            -- ANY FLOATING POINT TYPE
```

INSTRUCTOR NOTES

POINT OUT:

1. WHERE THE GENERIC PARAMETERS, GENERIC SPECIFICATION ARE

2. WHAT PARAMETERS CAN BE PASSED

GENERICS FOR REUSABLE MODULES

```
generic
   Stack_Size : Natural;                  -- GENERIC FORMAL OBJECT PARAMETER
   type Stack_Item is private;            -- GENERAL TYPE PARAMETER
package Stack is
   procedure Push (E : in Stack_Item);
   function Pop return Stack_Item;
   ...
end Stack;
```

INSTRUCTOR NOTES

EXAMPLES OF HOW WE COULD USE THE GENERIC STACK DEFINITION OF PREVIOUS SLIDE. RELATE THE ACTUAL TO FORMAL PARAMETERS. ONCE WE INSTANTIATE -- I.E. CREATE AN EXECUTABLE COPY -- WE CAN USE THE STACK.

TO USE THE GENERIC STACK

- A STACK OF INTEGERS

```
with Stack;
procedure Int_Stack_Example is
   N : Integer;
   package Integer_Stack is new Stack (20, Integer);   -- INSTANTIATION
begin -- Int_Stack_Example
   ...
   N := Integer_Stack.Pop;                               -- TO USE
end Int_Stack_Example;
```

- A STACK OF RECORDS

```
with Stack;
procedure Rec_Stack_Example is
   type CPU_Resource_Record_Type is ...;
   CPU_Resource_Record : CPU_Resource_Record_Type;
   package Resource_Stack is new Stack (100, CPU_Resource_Record_Type);
begin
   ...
   Resource_Stack.Push (CPU_Resource_Record);
end Rec_Stack_Example;
```

INSTRUCTOR NOTES

GENERICS FOR REUSABLE MODULES

ADDITIONAL EXAMPLES:

- QUEUES (BUFFERS, MONITORS)
- SEARCH AND SORT ALGORITHMS
- MAN-MACHINE INTERFACES (E.G. MENU DRIVEN SYSTEMS)

INSTRUCTOR NOTES

POINT OUT:

1. FORMAL ←→ ACTUAL PARAMETERS

2. THIS EXAMPLE ILLUSTRATES THE USE OF SUBPROGRAMS AS PARAMETERS

3. THIS IS HOW WE CAN PASS ARRAYS AS GENERIC PARAMETERS

4. "<" IS THE < DEFINED FOR THE ARRAY INDEXED BY Index_Type OF COMPONENTS OF TYPE ITEM

GENERICS TO PASS SUBPROGRAMS TO PROGRAM UNITS

```
generic

   type Index_Type is (< >);
   type Item is private;
   type List_Type is array (Index_Type) of Item;
   with function "<" (X, Y : Item) return Boolean is "< ";

procedure Sort (List : in out List_Type);
```

INSTRUCTOR NOTES

Integer_Sort USES THE DEFAULT "<" FUNCTION SPECIFIED IN THE TEMPLATE.

TO USE THE GENERIC SORT - INSTANTIATION

- AN ARRAY OF INTEGERS

```
-- WITH THE FOLLOWING DECLARATIONS

type Index is range 1 .. 10;
type Integer_Array_Type is array (Index) of Integer;

-- THE INSTANTIATION

procedure Integer_Sort is new Sort (Index_Type =>  Index,
                                    Item       =>  Integer,
                                    List_Type  =>  Integer_Array_Type);
```

INSTRUCTOR NOTES

THIS EXAMPLE IS AN IMPORTANT ONE. IT ILLUSTRATES NOT ONLY THE USE OF GENERICS BUT MORE IMPORTANTLY THE USE OF ADA TO STATE REQUIREMENTS. RESEARCH IN THIS AREA.

KEEP IN MIND THAT WE ARE GOING TO MODEL HARDWARE IN ADA. THE REQUIREMENTS ARE FIRMLY SPECIFIED. AT A LATER POINT WE CAN PARTITION FOR H/W OR S/W.

ESSENTIALLY A UART CONVERTS A BIT STREAM TO CHARACTERS AND VICE VERSA.

THIS EXAMPLE SPANS THREE SLIDES. INSTRUCTOR SHOULD BE FAMILIAR WITH THIS EXAMPLE BEFORE TRYING TO PRESENT IT.

GENERICS TO DETAIL DESIGN OPTIONS WHILE DEFERRING DESIGN DECISIONS

A UNIVERSAL ASYNCHRONOUS RECEIVER TRANSMITTER (UART) IS A CHIP THAT CONVERTS SERIAL OR PARALLEL INPUT INTO THE OPPOSITE, PARALLEL OR SERIAL OUTPUT. THE UART EXPECTS A CERTAIN OPERATING ENVIRONMENT WHICH LENDS ITSELF TO GENERIC PARAMETERS. A UART CAN BE SET FOR VARYING OPTIONS OF PARITY, BIT FORMAT, TRANSMIT AND RECEIVE BAUD RATES, VOLTAGES, SERIAL LINE REPRESENTATION. A UART COULD BE PART OF A COMMUNICATION SYSTEM CONSISTING OF HARDWARE AND SOFTWARE.

INSTRUCTOR NOTES

GO THROUGH CAREFULLY. THE COMMENTS EXPLAIN THE ACTUAL CODE.

TYPE Duration IS A PREDEFINED FIXED POINT TYPE (PACKAGE Standard) WHOSE VALUE IS EXPRESSED IN SECONDS.

THE DESIGN COULD BE REPRESENTED AS

```
generic
      -- Level is the number of bits in the character, indicating the
      -- type of code, such as Ascii, Baudot, etc.
      -- Receive_Baud_Rate indicates the incoming baud rate
      -- Transmit_Baud_Rate indicates the outgoing baud rate
      -- With_Parity indicates whether parity will be transmitted or
      -- received.  Either parity is present both for receive and for
      -- transmit or it is absent.
      -- Even_Parity indicates whether the parity will be even or odd.
      -- The type BIT models the voltage levels used for logical 0 and
      -- logical 1.
      -- Asynch_Input_Bit_Stream models the hardwired line from which the
      -- incoming bits will be read.
      -- Asynch_Output_Bit_Stream models the hardwired line on which the
      -- outgoing bits will be sent.
      -- SPACE represents a logical 0.
      -- MARK represents a logical 1.  SPACE and MARK are the names
      -- Traditionally used in asynchronous communication to represent
      -- these logical values.

      Level                  : Natural range 5 .. 8;
      Receive_Baud_Rate      : in Duration;
      Transmit_Baud_Rate     : in Duration;
      With_Parity            : in Boolean;
      Even_Parity            : in Boolean;
      Number_of_Stop_Bits    : Natural range 1 .. 2;

      type Bit is (<>);
      with function Asynch_Input_Bit_Stream return Bit;
      with procedure Asynch_Output_Bit_Stream (Xmit_Bit: in Bit);

      Space                  : in Bit;
      Mark                   : in Bit;
package UART is
      -- package specifications
end UART;
```

INSTRUCTOR NOTES

IF YOU NEED A UART WITH DIFFERENT OPTIONS, JUST INSTANTIATE ANOTHER VERSION OF UART. THE ESSENTIAL NATURE OR CHARACTERISTICS OF A UART HAVE BEEN CAPTURED IN THE GENERIC DEFINITION.

NOTE THE "with UART" IS NEEDED TO HAVE ACCESS TO THE IDENTIFIER UART IN THE INSTANTIATION.

UART INSTALLATION

WHEN THE UART DEVICE IS INSTALLED, THE PINS ARE SOLDERED WHICH ROUGHLY PARALLELS

A GENERIC INSTANTIATION, SUCH AS:

```
package My_UART_Specs is
   type Bit_Voltage is (Plus_12_V, Minus_12_V);
   function Pin_20_Serial_Input return Bit_Voltage;
   procedure Pin_25_Serial_Output (Xmit: Bit_Voltage);
end My_UART_Specs;


with UART, My_UART_Specs; use My_UART_Specs;
package My_UART is new UART (Level                    => 7,
                             Receive_Baud_Rate        => 300.0,
                             Transmit_Baud_Rate       => 110.0,
                             With_Parity              => True,
                             Even_Parity              => True,
                             Number_of_Stop_Bits      => 1,
                             Bit                      => Bit_Voltage,
                             Asynch_Input_Bit_Stream  => Pin_20_Serial_Input,
                             Asynch_Output_Bit_Stream => Pin_25_Serial_Output,
                             Space                    => Plus_12_V,
                             Mark                     => Minus_12_V);
```

INSTRUCTOR NOTES

IN CONCLUSION

IN THIS WAY THE ACTUAL HARDWARE/SOFTWARE PARTITIONING CAN BE POSTPONED UNTIL THE DESIGN IS MORE COMPLETE.

THE DESIGN CAN BE USED FOR MANY CONFIGURATIONS OF THE ACTUAL COMMUNICATION SYSTEM AND THE DESIGN OPTIONS ARE EXPLICITLY REFLECTED IN THE ADA CODE.

INSTRUCTOR NOTES

PEOPLE TRANSITIONING FROM A LANGUAGE (SAY FORTRAN, PASCAL) THAT PROHIBITS THE PASSING OF DATA TYPES TO PROCEDURE MIGHT TRY TO IMPLEMENT IT VIA A VARIANT RECORD AS A PARAMETER RATHER THEN WITH THE DIRECT ADA FACILITY -- GENERIC SUBPROGRAMS.

SOME POTENTIAL PITFALLS - GENERICS

- USE OF ONE SUBPROGRAM WITH A CONTROL PARAMETER INDICATING THE TYPE OF THE ARGUMENTS, RATHER THAN A GENERIC SUBPROGRAM.

FOR EXAMPLE,

```
type Arg_Type is (Integer_Type, Real_Type, ...);
type Phony_Rec (Tag : Arg_Type) is
   record
      case Tag is
         when Integer_Type => Integer_Stuff : Integer;
         when Real_Type => Real_Stuff : Real;
         ...
       end case;
   end record;
procedure Put (What_Type : Phony_Rec);
```

RATHER THAN,

```
generic
   type Arg_Type is private;
   ...
procedure Put (What_Type : Arg_Type);
```

ALLOW 5-10 MINUTES.

SOLUTION:

```
generic
   type Index_Type is (<>);  -- ANY DISCRETE TYPE
   type Integer_Type is range (<>);  -- Integer'Last .. Integer'First
   type Array_Type is (Index_Type range <>) of Integer_Type;
function Sum (A : Array_Type) return Integer_Type;

function Sum (A : Array_Type) return Integer_Type is

   Result : Integer_Type := 0;

begin -- Sum

   for I in A'Range loop
      Result := Result + A(I);
   end loop;
   return Result;

end Sum;
```

PURPOSE:

1. WITHOUT GENERICS, A SEPARATE FUNCTION WOULD BE NEEDED FOR EACH ARRAY TYPE

2. ILLUSTRATE POINT MADE AT BEGINNING OF THIS SECTION, EFFECTIVE USE OF COMMON CODE.

3. GENERICS MAY BE MORE READABLE AND REFLECT THE REAL-WORLD SITUATION MORE CLOSELY.

EXERCISE

WRITE A GENERIC FUNCTION THAT SUMS THE ELEMENTS OF A ONE DIMENSIONAL ARRAY HAVING ANY INTEGER COMPONENT TYPE AND ANY INDEX TYPE.

INSTRUCTOR NOTES

Section 9
INPUT/OUTPUT

INSTRUCTOR NOTES

THIS ALLOWS THE PROGRAMMER TO WRITE HIS/HER OWN I/O PACKAGES, FOR EXAMPLE A FORMATTING PACKAGE, OR FOR NON-STANDARD PERIPERALS.

INPUT/OUTPUT

- ACCESSED THROUGH PACKAGES (PREDEFINED AND USER-DEFINED)
- USER HAS COMPLETE CONTROL OF I/O
- I/O IS NOT LIMITED TO COMPUTER PERIPHERALS

INSTRUCTOR NOTES

EXAMPLES OF I/O OPERATIONS: READ, WRITE, GET, PUT.

INPUT/OUTPUT - BASIC ASPECTS

- I/O IS BY NATURE MACHINE DEPENDENT

- PACKAGE SPECIFICATIONS PROVIDE THE INTERFACE FOR COMMON I/O OPERATIONS

- PACKAGE BODIES IMPLEMENT THE I/O OPERATION IN WAYS APPROPRIATE TO INDIVIDUAL COMPUTERS

INSTRUCTOR NOTES

I/O PACKAGES SUPPLIED WITH THE LANGUAGE ARE VERY PRIMITIVE.

BY TEXT FILES WE MEAN CHARACTERS - ASCII I/O.

I/O PACKAGES SUPPLIED BY LANGUAGE

- Text_IO - FOR I/O ON TEXTUAL (I.E. READABLE) FILES
- Sequential_IO - FOR I/O ON SEQUENTIAL ACCESS FILES (EXAMPLE: TAPES)
- Direct_IO - FOR I/O ON DIRECT ACCESS FILES (EXAMPLE: ISAM FILES)

INSTRUCTOR NOTES

SINCE WE CAN CREATE OUR OWN TYPES HOW CAN WE HAVE A PROCEDURE ALREADY AVAILABLE -- GENERICS ALLOWS US TO PASS THE EXACT TYPE AND CREATE ACTUAL I/O PACKAGES AS NEEDED.

TEXT_IO

- PERFORMS SIMPLE I/O OPERATIONS (Get, Put)

- TO USE TEXT_IO FACILITIES, MUST HAVE ACCESS TO THE PACKAGE FOR TEXT_IO

    -- AT TOP OF COMPILATION UNIT:

```
with Text_IO; use Text_IO;
```

- PACKAGE TEXT_IO PROVIDES

    -- I/O FOR Character AND String TYPES

    -- GENERIC I/O TEMPLATES FOR Integer, Enumeration, Floating, and Fixed Point TYPES.

INSTRUCTOR NOTES

STEP THROUGH QUICKLY HOW I/O FOR NUMERIC TYPES WORKS.

THE CONCEPT HERE IS THAT I/O IS TYPE DEPENDENT.

USING TEXT_IO FOR NUMERIC TYPES

EXAMPLE:

```
with Text_IO; use Text_IO;          -- PROVIDES ACCESS TO GENERIC I/O TEMPLATES
procedure Do_Sum is

   type My_Integer is range 10 .. 50;

   Value_1, Value_2 : My_Integer;

   package My_Int_IO is new Integer_IO (My_Integer);  -- INSTANTIATE A COPY TO
   use My_Int_IO;                                  -- PROVIDE I/O FOR OBJECTS OF TYPE
                                                   -- My_Integer

begin -- Do_Sum

   Get (Value_1);
   Get (Value_2);
   Put (Value_1 + Value_2);

end Do_Sum;
```

NOTE:

- FOR FLOATING POINT TYPES THE GENERIC PACKAGE IS Float_IO
- FOR FIXED POINT TYPES THE GENERIC PACKAGE IS Fixed_IO

INSTRUCTOR NOTES

GO THROUGH THIS EXAMPLE. MANAGERS NEED A FEEL FOR HOW THIS WORKS FOR ENUMERATION TYPES.

USING TEXT_IO FOR ENUMERATION TYPES

```
with Text_IO; use Text_IO;
procedure Name_Next_Month is

   type Month_Type is (January, February, March, April, May, June, July, August,
                       September, October, November, December);

   package Month_IO is new Enumeration_IO (Month_Type);
   use Month_IO;

   This_Month, Next_Month: Month_Type;

begin -- Name_Next_Month

   Get (This_Month);                                          -- Get IS AVAILABLE
   if This_Month = December then
              Next_Month := January;
   else
              Next_Month := Month_Type'Succ (This_Month);
   end if;
   Put (Next_Month);                                          -- Put IS AVAILABLE

end Name_Next_Month;
```

INSTRUCTOR NOTES

USING TEXT_IO FOR ARRAY AND RECORD TYPES

- NONE IS PREDEFINED (EXCEPT FOR String)
- MUST DO COMPONENT BY COMPONENT

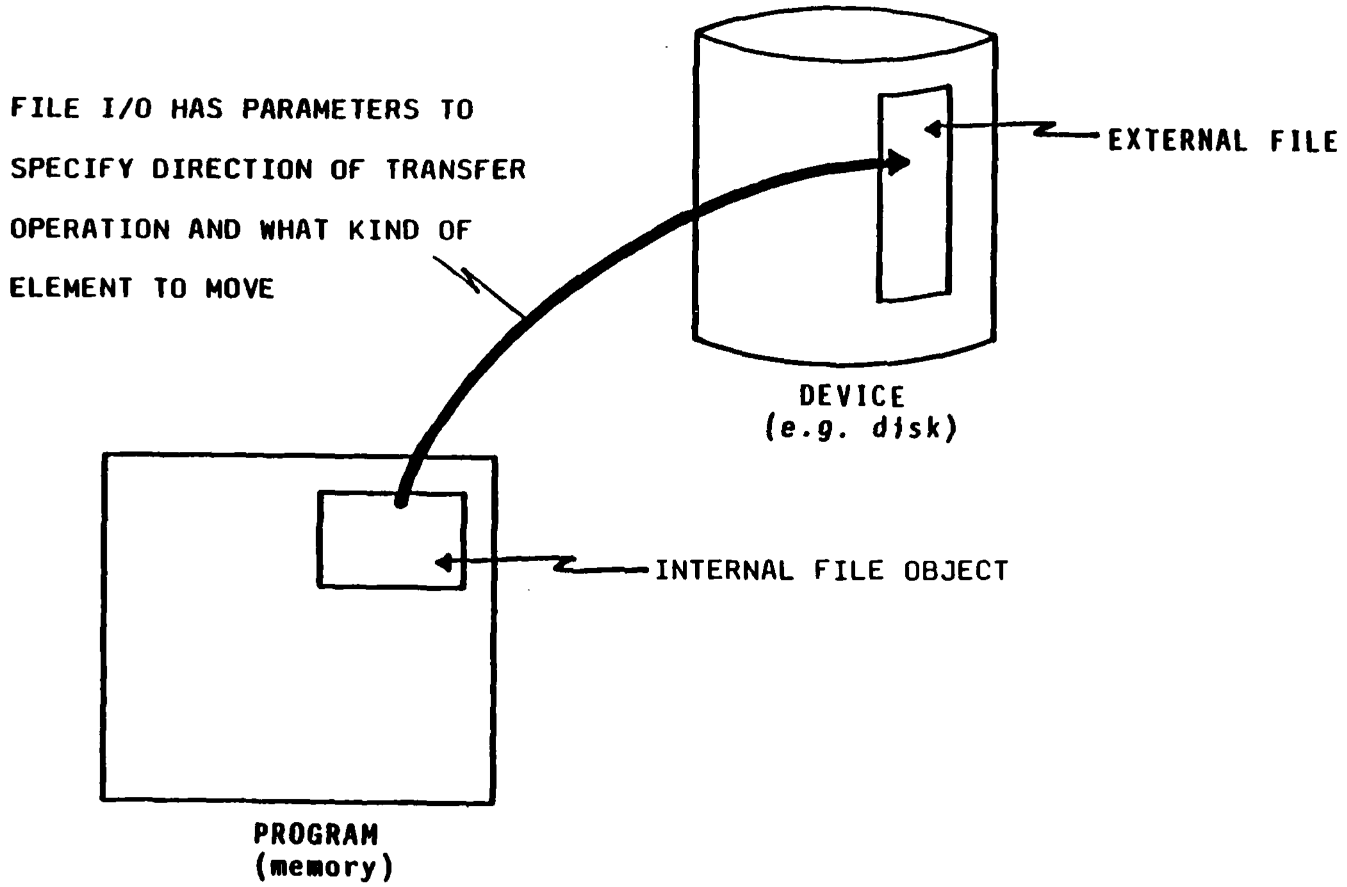
(STYLE HINT: DEFINE YOUR OWN PROCEDURES CALLED Put AND Get.)

INSTRUCTOR NOTES

THIS IS A SNAP-SHOT OF HOW FILE I/O IS VIEWED IN ADA. DON'T DWELL ON SLIDE. THE FOLLOWING IS INFORMATION PRIMARILY FOR THE INSTRUCTION:

- EXTERNAL FILE - ANYTHING OUTSIDE THE PROGRAM THAT CAN PRODUCE A VALUE FOR INPUT OR ACCEPT A VALUE FOR OUTPUT.
- INTERNAL FILE - OBJECT WITHIN THE PROGRAM ABLE TO BE ASSOCIATED WITH AN EXTERNAL FILE.
- FILE - REFERS TO THE INTERNAL FILE
- OPEN FILE - INTERNAL FILE ASSOCIATED WITH AN EXTERNAL FILE
- CLOSED FILE - INTERNAL FILE NOT ASSOCIATED WITH AN EXTERNAL FILE

WHAT IS A FILE



FILE I/O HAS PARAMETERS TO SPECIFY DIRECTION OF TRANSFER OPERATION AND WHAT KIND OF ELEMENT TO MOVE

INSTRUCTOR NOTES

CREATE

Create ESTABLISHES A NEW EXTERNAL FILE AND ASSOCIATES IT WITH AN INTERNAL FILE

OPEN

Open OPENS AN INTERNAL FILE BY ASSOCIATING IT WITH AN EXISTING EXTERNAL FILE

CLOSE

Close SEVERS THE ASSOCIATION BETWEEN INTERNAL AND EXTERNAL FILES

DELETE

Delete DELETES THE EXTERNAL FILE ASSOCIATED WITH THE GIVEN INTERNAL FILE AND CLOSES THE INTERNAL FILE

RESET

Reset RESTARTS READING/WRITING AT THE BEGINNING OF THE FILE

BASIC FILE COMMANDS

- VARIOUS COMMANDS ARE AVAILABLE FOR BASIC FILE OPERATIONS. FOR EXAMPLE:

CREATE

OPEN

CLOSE

DELETE

RESET

INSTRUCTOR NOTES

COMMANDS FOR FILE INFORMATION

- VARIOUS COMMANDS ARE AVAILABLE TO OBTAIN FURTHER FILE INFORMATION.

  FOR EXAMPLE:

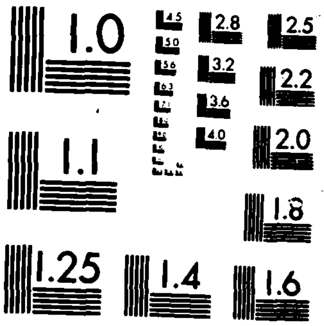
  MODE OF FILE

  NAME OF A FILE

  IS A FILE OPEN?

  END OF FILE

AD-A165 315   ADA (TRADEMARK) TRAINING CURRICULUM ADA (REGISTERED   2/5
TRADEMARK) FOR SOFTWARE MANAGERS L201 TEACHER'S GUIDE
VOLUME 2(U) SOFTECH INC WALTHAM MA 1986
UNCLASSIFIED   DAAB07-83-C-K506   F/G 5/9   NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

INSTRUCTOR NOTES

PROVIDE I/O FOR ARRAY AND RECORDS AS A WHOLE (I.E. NOT COMPONENT BY COMPONENT AS WITH Text_IO) WHEN YOU DON'T NEED TO READ IT.

SEQUENTIAL_IO

- ALLOWS BINARY INPUT/OUTPUT ON SEQUENTIAL ACCESS FILES

- HAS A "CURRENT INDEX" WHICH IS SEQUENTIALLY INCREMENTED WHICH CANNOT BE INCREMENTED BY THE USER

- MAJOR OPERATIONS ARE Read AND Write

- IS A LIBRARY UNIT AND MUST BE IMPORTED VIA A with CLAUSE

  EXAMPLE: with Sequential_IO;

- IS A GENERIC PACKAGE AND MUST BE INSTANTIATED WITH A type

  EXAMPLE:

  ```
  type Array_Type is array (1 .. 10) of Boolean;
  package Arr_IO is new Sequential_IO (Array_Type);
  use Arr_IO;
  ```

INSTRUCTOR NOTES

ALSO USE FOR COMPOSITE TYPE (ARRAYS, RECORDS) I/O.

DIRECT_IO

- ALLOWS BINARY INPUT/OUTPUT ON DIRECT ACCESS FILES

- HAS A CURRENT INDEX WHICH CAN BE DIRECTLY CHANGED BY THE USER

- MAJOR OPERATIONS ARE Read AND Write

- IS A LIBRARY UNIT WHICH MUST BE IMPORTED VIA A with CLAUSE

```
EXAMPLE:  with Direct_IO;
```

- IS A GENERIC PACKAGE WHICH MUST BE INSTANTIATED WITH A TYPE

```
EXAMPLE:  type Array_Type is array (1 .. 10) of Boolean;
          package Arr_IO is new Direct_IO (Array_Type);
          use Arr_IO;
```

INSTRUCTOR NOTES

I/O SUMMARY

- I/O PROVIDED AS PACKAGES
- THREE KINDS ARE PROVIDED WITH THE LANGUAGE

  Text_IO,

  Sequential_IO

  Direct_IO
- USER CAN CREATE OWN I/O AS NEEDED

INSTRUCTOR NOTES

SOME POTENTIAL PITFALLS - I/O

- I/O IN ADA IS VERY PRIMITIVE

  FOR EXAMPLE:

  IT WILL BE VERY DIFFICULT TO DEBUG REPORT GENERATION PROGRAMS

  NOTE: MOST MANAGERS WILL MOST LIKELY HAVE THEIR OWN I/O PACKAGES DEFINED

INSTRUCTOR NOTES

Section 10
EXCEPTIONS

INSTRUCTOR NOTES

EXCEPTIONS -- BASIC IDEA

- AN EXCEPTION STOPS SEQUENTIAL EXECUTION WHEN A PARTICULAR CONDITION IS REACHED, AND TRANSFERS CONTROL TO SOME KNOWN LOCATION WHERE THE CONDITION MAY BE HANDLED

- A MECHANISM FOR FAULT-TOLERANT PROGRAMMING

  ALTERNATIVE TO EXPLICIT ERROR CODE PARAMETERS

  LANGUAGE ALLOWS DIRECT REPRESENTATION OF REAL WORLD ALGORITHM

- PREDEFINED AND USER-DEFINED EXCEPTIONS

- SUPPORTS RELIABILITY

INSTRUCTOR NOTES

EXCEPTIONS

CAN BE USED TO

- DETECT AND RECOVER FROM EXCEPTIONAL OR ERROR CONDITIONS
- PERFORM "CLEANUP" ACTIONS FOR HARDWARE MALFUNCTIONS

INSTRUCTOR NOTES

MOTIVATION FOR EXCEPTION HANDLING ALTERNATIVES.

EXCEPTION EXAMPLE

- WHEN DIVISOR IS ZERO AN EXCEPTION (CALLED Numeric_Error) WILL OCCUR

```
procedure Example (Dividend, Divisor            :  in Float;
                   Partial_Result, Final_Result  :  out Float) is
       . . .
begin -- Example
       . . .
       Partial_Result  := Dividend/Divisor;
       . . .
       Final_Result := Partial_Result + 1.0;
end Example;
-----------------------------------------------------------------
with Example;
procedure Main is
       A, B, C, D  :  Float;
       . . .
begin -- Main
       . . .
       Example (A, B, C, D);
       . . .
end Main;
```

INSTRUCTOR NOTES

WHEN THE ERROR IN THE EXAMPLE OCCURS, WHAT CAN WE DO ...

WHAT COULD BE DONE?

HANDLE THE EXCEPTIONS LOCALLY IN Example: SET Partial_Result AND Final_Result TO Float'Last AND RETURN TO PROCEDURE Main AS IF NOTHING UNUSUAL HAD HAPPENED

OR

TERMINATE EXECUTION OF PROCEDURE Example AND MAKE SITUATION KNOWN TO Main SO THAT IT CAN TAKE CORRECTIVE ACTION

OR

PASS THE PROBLEM TO THE OPERATING SYSTEM AND LET IT DO SOMETHING LIKE TERMINATE THE PROGRAM WITH AN ERROR MESSAGE

- NONE OF THE ABOVE CHOICES IS RIGHT FOR EVERY APPLICATION

SO

- ADA ALLOWS THE PROGRAMMER TO CONTROL THE HANDLING OF EXCEPTIONS

INSTRUCTOR NOTES

IN GENERAL

- TO CONTROL THE HANDLING OF EXCEPTIONS WE'D LIKE TO

  1) NAME EXCEPTIONAL SITUATIONS

  2) CALL ATTENTION SOMEWHERE TO THE FACT THAT AN EXCEPTIONAL SITUATION OCCURRED

  3) ATTEMPT TO CORRECT THE SITUATION

- THESE ACTIONS ARE MAPPED TO ADA EXCEPTION CONSTRUCTS AS FOLLOWS:

  1) EXCEPTION DECLARATION

  2) raise STATEMENT

  3) EXCEPTION HANDLER

INSTRUCTOR NOTES

PREDEFINED EXCEPTIONS MEAN THE NAME OF THE EXCEPTIONAL EVENT AND HOW IT IS MADE KNOWN (I.E. RAISED) ARE DETERMINED BY THE LANGUAGE.

BE AWARE THAT NOT ALL THE PREDEFINED EXCEPTIONS MUST BE RAISED (E.G. NUMERIC ERROR) BY AN IMPLEMENTATION.

ONLY EXPLAIN THE PREDEFINED EXCEPTIONS FOR CONSTRAINT, NUMERIC, PROGRAM AND DATA.
EXAMPLES:

- CONSTRAINT: TRYING TO ASSIGN 10 TO A VARIABLE DECLARED AS

```
X : Integer range 0 .. 5;
```

- PROGRAM: TRY TO EXIT A FUNCTION OTHER THAN BY A RETURN OR ANOTHER EXCEPTION

```
begin
   if ... then
      return ...;
   else
      ...         -- no return
   end;
```

PREDEFINED LANGUAGE EXCEPTIONS

THERE EXIST FIVE PREDEFINED LANGUAGE EXCEPTIONS:

- Constraint_Error - OBJECT VALUES OUTSIDE RANGE OR INDEX CONSTRAINT
- Numeric_Error - NUMERIC OPERATION GIVES AN INCORRECT MATHEMATICAL RESULT
- Program_Error - TRYING TO ACTIVATE OR USE A PROGRAM UNIT THAT IS NOT ACTIVATED
- Storage_Error - INSUFFICIENT MEMORY TO ALLOCATE AN OBJECT OR PROGRAM UNIT
- Tasking_Error - TASK RELATED ERROR

EXCEPTIONS FOR I/O EXIST. FOR EXAMPLE:

- Data_Error - DATA OF THE INCORRECT TYPE IS ENTERED

INSTRUCTOR NOTES

AN EXCEPTION HANDLER IS AN ATTEMPT TO TAKE SOME CORRECTIVE ACTION FOR AN EXCEPTIONAL EVENT.

EXCEPTION HANDLER

AN EXCEPTION HANDLER OCCURS IN A "FRAME"

```
            ⎧  begin
            ⎪
            ⎪         -- sequence of statements
            ⎪
  FRAME     ⎨  exception
            ⎪
            ⎪
            ⎪         -- exception handlers
            ⎪
            ⎩  end;
```

INSTRUCTOR NOTES

FIRST SHOW FRAME SYNTAX THEN STEP THROUGH WHAT HAPPENS IF AN EXCEPTION IS RAISED.

BUT LET'S SAY WE WANT TO EXECUTE THE STATEMENTS INDICATED BY THE '...' EVEN IF THE EXCEPTION IS RAISED. WHAT CAN WE DO? (NEXT SLIDE).

EXCEPTION HANDLING EXAMPLE

```
with Text_IO; use Text_IO;
procedure Expand_Command is

      ...

begin -- Expand_Command

      Get (Input_Character);

      ...                                -- THESE STATEMENTS NOT EXECUTED IF
                                         -- Data_Error IS RAISED

exception

      when Data_Error =>  Put_Line ("Invalid Entry");

end Expand_Command;
```

INSTRUCTOR NOTES

BLOCK STATEMENT

- BLOCKS PROVIDE A MECHANISM FOR LOCALIZING EXCEPTION HANDLER(S) TO A STATEMENT OR SEQUENCE OF STATEMENTS

SYNTAX:

```
[Block_Name:]
[declare
        local declarations;]
begin   -- Block_Name
        sequence_of_statements;
[exception
        exception_handler;
       {exception_handler;}]
end [Block_Name];
```

INSTRUCTOR NOTES

A BLOCK IS ALSO A FRAME IN WHICH WE CAN PUT EXCEPTION HANDLERS.

GO THROUGH WHAT HAPPENS WITH THIS VERSION.

EXAMPLE WITH BLOCK

```
with Text_IO; use Text_IO;
procedure Expand_Command is
       ...

begin -- Expand_Command

       loop  -- additional data entry trys allowed for incorrectly entered data


              begin

                     Get (Input_Character);

                     exit;  -- when all goes well.

              exception

                     when Data_Error =>  Put_Line ("Invalid Entry");

                                         Put_Line ("Try Again");

              end;

       end loop;

              ...  -- only executed when valid data is entered

end Expand_Command;
```

INSTRUCTOR NOTES

USER-DEFINED EXCEPTIONS

EXCEPTION DECLARATION

SYNTAX:

```
Exception_Name {,Exception_Name} :  exception;
```

EXAMPLES:

```
Division_By_Zero          :  exception;
CRC_Failure, Sensor_Off :  exception;
```

INSTRUCTOR NOTES

RAISE STATEMENT

- PREDEFINED EXCEPTIONS ARE AUTOMATICALLY RAISED BY THE LANGUAGE (OR Text_IO)

- TO RAISE USER DEFINED EXCEPTIONS USE THE raise STATEMENT

SYNTAX:

```
raise [Exception_Name];
```

EXAMPLES:

```
raise Division_By_Zero;
raise;          -- only in a handler
raise Sensor_Off;
```

INSTRUCTOR NOTES

DON'T GO THROUGH EXAMPLE, JUST SHOW THE USE AND MEANING OF THE BAR IN AN EXCEPTION HANDLER SO THEY WOULD UNDERSTAND IT IF THEY SAW IT IN AN EXAMPLE. DO THE SAME FOR THE 'others' OPTION.

ALTERNATE NOTATION CHOICES IN HANDLERS

SYNTAX:

```
when exception_choice  {|exception_choice} =>
        -- sequence of statements
```

EXAMPLE:

```
begin
        ...
exception
        when Division_By_Zero =>
                -- sequence of statements
                -- to be executed when Divisor = 0.0
        when CRC_Failure | Sensor_Off =>
                -- sequence of statements to be executed
                -- whenever the exceptions CRC_Failure or
                -- Sensor_Off are raised
        when others =>
                -- sequence of statements to be executed when an
                -- exception other than one of those listed above
                -- is raised
end;
```

INSTRUCTOR NOTES

THIS IS THE TYPE OF EXCEPTION HANDLING WE'VE LOOKED AT SO FAR SO STEP THROUGH QUICKLY.

EXCEPTION HANDLING CONTROL FLOW
LOCAL HANDLING

```
procedure Example ( Dividend, Divisor                  :  in Float;
                    Partial_Result, Final_Result       :  out Float) is
     Division_By_Zero  :  exception;          -- exception declaration
begin -- Example
     . . .
     if Divisor = 0.0
     then
          raise Division_By_Zero;             -- raising the exception
     else
          Partial_Result  := Dividend/Divisor;
     end if;
     . . .
     Final_Result := Partial_Result + 1.0;
exception                                     -- exception handler
     when Division_By_Zero =>
          Partial_Result := Float'Last;
          Final_Result   := Float'Last;
end Example;
```

INSTRUCTOR NOTES

WHEN NEEDED, WE CAN MAKE THE EXCEPTIONAL SITUATION KNOWN TO A 'hyphen' PROGRAM LEVEL (IN ADA JARGON, PROPAGATED).

STEP THROUGH THE CONTROL FLOW CAREFULLY.

EXCEPTION HANDLING CONTROL FLOW PROPAGATED TO CALLER

```
procedure Example ( Dividend, Divisor                :  in Float;
                    Partial_Result, Final_Result     :  out Float) is
       Division_By_Zero  :  exception;                  -- exception declaration
       . . .
begin -- Example
       . . .
       if Divisor = 0.0
       then
              raise Division_By_Zero;                   -- raising the exception
       else
              Partial_Result := Dividend/Divisor;
       end if;
       . . .  -- calculations
end Example;                                            -- no exception handler so
                                                        -- exception propogated

----------------------------------------------------------------------

with Example;
procedure Main is
       A, B, C, D  :  Float;
       . . .
begin -- Main
       . . .
       Example (A, B, C, D);
       . . .                    -- these will not be executed if
                                -- Division_By_Zero is raised in Example.
exception
       when others =>
       ... -- whatever          -- exception handler
end Main;
```

INSTRUCTOR NOTES

THIS SUMMARIZES THE FLOW OF CONTROL WHEN HANDLING EXCEPTIONS. DON'T GO THROUGH. IT'S HERE FOR FUTURE REFERENCE.

EXCEPTION HANDLING CONTROL FLOW SUMMARY

- WHEN AN EXCEPTION IS RAISED, NORMAL PROGRAM EXECUTION IS SUSPENDED
- IF THERE IS A HANDLER FOR THE EXCEPTION IN THE INNERMOST FRAME, CONTROL IS TRANSFERRED TO IT
- IF THERE IS NO HANDLER, THE EXCEPTION IS PROPAGATED UP TO THE FRAME THAT CAUSED THE FRAME INCURRING THE EXCEPTION TO BE INVOKED -- THE CALLER IN THE CASE OF A SUBPROGRAM OR THE SURROUNDING FRAME IN THE CASE OF A BLOCK
- IF A HANDLER IS FOUND THERE IT IS EXECUTED. IF NOT, THE EXCEPTION IS PROPAGATED UP ONE MORE LEVEL
- IF NO HANDLER IS FOUND IN THE PROGRAM, THE UNDERLYING OPERATING SYSTEM TERMINATES THE PROGRAM (AND CAN TAKE OTHER ACTIONS SUCH AS ISSUING ERROR MESSAGES)
- WHEN A HANDLER IS FOUND, THE EXECUTION OF THE HANDLER REPLACES EXECUTION OF THE FRAME CONTAINING THE HANDLER (AND ANY LOWER LEVEL FRAMES)

INSTRUCTOR NOTES

HERE IS A REAL-TIME EXAMPLE OF THE USE OF EXCEPTIONS. EXAMPLE IS FROM A COMMUNICATION SYSTEM WHICH RECEIVES, PROCESSES, AND THEN ROUTES TO THE APPROPRIATE DESTINATIONS THE MESSAGE. ALGORITHM: A MESSAGE NODE IS SEIZED AND LOCKED DURING MESSAGE TRANSMISSION.

NOTE: WE ASSUME THAT Message_Error CAN ONLY BE RAISED BY Send_Message.

STEP THROUGH EXAMPLE AS THIS IS THE BASIS OF THE EXERCISE.

EXCEPTIONS TO DETECT AND RECOVER FROM EXCEPTIONAL OR ERROR CONDITIONS

```
begin
   loop
      if Receiving_A_Message then
         Process_Message;
      elsif Sending_A_Message then
         Seize (Message_Node);
         Send_Message (Message);         -- Message_Error raised here
         Free (Message_Node);
      end if;
   end loop;
exception
   when Message_Error =>
      Free (Message_Node);
      Notify_Operator;
end;
```

INSTRUCTOR NOTE

SOLUTION

```
loop
   if ... then ...
   elsif ... then
      Seize (Message_Node);
      begin
         Send_Message (Message_Node);
         Free (Message_Node);
      exception
         when others =  Free (Message_Node);
                        Notify_Operator;
      end;
   end if;
end loop;
```

NOTE: BULLET ONE IMPLIES THAT SEIZE COULD RAISE AN EXCEPTION. WE MIGHT NOT WANT TO FREE A NODE THAT HAD NOT REALLY BEEN SEIZED. THIS IS WHY WE WOULD NOT WANT SEIZE TO BE WITHIN THE BLOCK WITH THE EXCEPTION HANDLER. THE OTHERS IS USED IN THE HANDLER RATHER THAN Message_Error TO SATISFY BULLET TWO. Send_Message COULD RAISE OTHER EXCEPTIONS. BUT WHATEVER THE ERROR WE ALWAYS WANT TO FREE THE NODE.

EXERCISE

ASSUMING THAT THE SOURCE OF ALL POSSIBLE EXCEPTIONS IS KNOWN IS NOT A SAFE PRACTICE.

MODIFY THE PREVIOUS EXAMPLE SO THAT

- Free IS ONLY CALLED WHEN THE NODE HAS BEEN SEIZED

- Free IS CALLED NO MATTER WHAT EXCEPTION IS RAISED BY Send_Message

INSTRUCTOR NOTES

EXCEPTIONS TO PERFORM "CLEANUP" AFTER HARDWARE MALFUNCTIONS

```
procedure Tape_Read (Tape : in Tape_File_Type;
                     Disk : out Disk_File_Type) is
   ...
   Read_Error : exception;
   ...
begin -- Tape_Read
   -- Read_Error raised on a H/W misread
   ...
exception
   when Read_Error => Backspace (Tape);
                      Re_Read (Tape);
end Tape_Read;
```

INSTRUCTOR NOTES

THIS SECTION IS VERY IMPORTANT. EXCEPTIONS CAN BE USED/MISUSED IN SO MANY WAYS. THEIR USE SHOULD AGAIN BE WITH DELIBERATE INTENT AND PLANNED INTO THE SYSTEM DESIGN (NOT ADDED AT THE LAST MINUTE WHEN ERRORS START OCCURRING).

GENERAL ISSUES WITH EXCEPTION HANDLERS

- AN "EASY" FIX WHICH AFFECTS ONLY LOCAL OBJECTS SHOULD BE HANDLED LOCALLY (E.G.: DATA_ERROR)

- A CATASTROPHIC FAILURE MIGHT NEED TO BE PROPAGATED TO AND HANDLED AT A HIGHER LEVEL

  EXAMPLE:

  > A TAPE READ ERROR MAY WISH TO BACKSPACE AND TRY TO REREAD THE TAPE (LOCAL FIX), OR IF THAT FAILS, MAY WANT TO INITIATE A RECONFIGURATION (GLOBAL FIX)

- COMPLETELY UNEXPECTED EXCEPTIONS REVEAL A SOFTWARE ERROR AND SHOULD BE TREATED AT A HIGHER LEVEL

INSTRUCTOR NOTES

GENERAL ISSUES WITH EXCEPTION DECLARATIONS

- TYPICALLY, A PACKAGE SPECIFICATION DECLARES EXCEPTIONAL SITUATIONS THE PACKAGE OPERATIONS IN THE BODY RAISE THE EXCEPTIONS

- ONLY DECLARE LOCALLY A CONDITION THAT COULD BE HANDLED LOCALLY (RARELY IS THIS THE CASE.)

- BY USING USER DEFINED EXCEPTIONS CAN DETERMINE WHAT CONDITION TRIGGERED IT

INSTRUCTOR NOTE

GENERAL ISSUES (Continued)

- EXCEPTIONS ARE A HIGH-LEVEL DESIGN ISSUE

- APPLICATION SPECIFIC OR ORGANIZATION SPECIFIC POLICIES FOR DESIGNER AND PROGRAMMERS ARE NECESSARY

- RULE OF THUMB: EXCEPTIONS EXIST TO PROVIDE AN ADDED LEVEL OF PRECAUTION, NOT AN OPPORTUNITY FOR PLAYING GAMES WITH CONTROL FLOW.

  - AT MODULE INTERFACES, THE CALLED MODULE SHOULD "RETURN" AN EXCEPTION FOR ALL INVALID CALLS.

  - EXCEPTION HANDLERS SHOULD BE USED TO PREVENT UNEXPECTED MODULE EXIT AT CRITICAL TIMES. E.G., A PROGRAM UNIT THAT OPENS A FILE SHOULD ALWAYS HAVE AN EXCEPTION HANDLER THAT CLOSES THE FILE ... JUST IN CASE.

INSTRUCTOR NOTES

THESE TECHNICAL MANAGERS ARE IN THE POSITION TO SET THESE POLICIES -- AS SUCH THEY NEED TO BE AWARE OF THE PROBLEMS. THERE ARE NO SET ANSWERS FOR A GIVEN APPLICATION, UNFORTUNATELY.

SOME POTENTIAL PITFALLS - EXCEPTIONS

- ASSUMING THAT AN EXCEPTION COMES FROM ONLY A KNOWN PLACE

```
procedure Search (S: String; C: Character) is
   Position : Integer := S'First;
begin -- Search
   while S(Position) /= C loop
      Position := Position + 1;
   end loop;
   Found (Where => Position);
exception
   when Constraint_Error => Not_Found;
end Search;
```

NOTE: THE PROGRAMMER ASSUMES THAT Constraint_Error WILL BE RAISED BY Position INDEXING OUT OF THE BOUNDS OF S. IN FACT, IT COULD BE UNEXPECTEDLY RAISED BY Found AND PROPAGATED BACK TO Search (IF THERE IS NO HANDLER IN Found).

INSTRUCTOR NOTES

PITFALLS (Continued)

- USING EXCEPTIONS TO SIMULATE (HIDE) A GOTO. (SYMPTOM: EXCEPTION RAISED AND HANDLED IN SAME UNIT)
- NOT PERFORMING ADEQUATE ERROR CHECKING AT MODULE INTERFACES
- NOT PROVIDING EXCEPTION HANDLERS FOR MODULES THAT ALLOCATE SYSTEM-WIDE RESOURCES
- USING others IN AN EXCEPTION HANDLER AS A CATCH-ALL

INSTRUCTOR NOTE

THIS IS A CONTROVERSIAL USE OF EXCEPTIONS. MANAGER MAY HAVE TO DECIDE ON THE APPROPRIATE USE FOR THEIR ORGANIZATION OR PROJECT. THIS COULD BE CODED AS

```
begin -- Tomorrow
   if D /= Days'Last then
      return Days'Succ (D);
   else
      return Days'First;
end Tomorrow;
```

THE ISSUES ARE:

1. WHICH IS CLEARER CODE (FOR UNDERSTANDING ITS FUNCTIONING) FOR THE MAINTAINER

2. ARE EXCEPTIONS ONLY FOR EXCEPTIONAL SITUATIONS

PITFALLS (Continued)

- USING EXCEPTIONS TO DETECT AND RECOVER FROM EXPECTED CONDITIONS

```
...
type Days is (Mon, Tue, Wed, Thu, Fri, Sat, Sun);
...
function Tomorrow (D : Days) return Days is
begin -- Tomorrow
      return Days'Succ (D);
exception
   when Constraint_Error =>
      return Days'First;  -- Constraint_Error Raised
end Tomorrow;
```

INSTRUCTOR NOTES

Section 11
STUBBING

VG 823.1

INSTRUCTOR NOTES

STUBBING

CAN BE USED TO

- INCREASE UNDERSTANDABILITY OF COMPLEX CODE AND DESIGN
- LOCALIZE LIBRARY UNIT INFORMATION
- DECREASE RECOMPILATION COSTS

INSTRUCTOR NOTES

STUBBING BY EXAMPLE

NESTED

```
procedure Calculate_Median (...) is
   --
   -- local declarations
   --
   procedure Sort (...) is
      --
      -- local declarations
      --
   begin -- Sort
      ...
   end Sort;
begin -- Calculate_Median
   ...
end Calculate_Median;
```

STUB

```
procedure Calculate_Median (...) is
   --
   -- local declarations
   --
   procedure Sort (...) is separate;
begin -- Calculate_Median
   ...
end Calculate_Median;
```

SUBUNIT

```
separate (Calculate_Median)
procedure Sort (...) is
   ...
begin -- Sort
   ...
end Sort;
```

INSTRUCTOR NOTES

STUBS AND SUBUNITS

- AT THE POINT WHERE A SUBPROGRAM BODY OR PACKAGE BODY WOULD NORMALLY APPEAR IN A COMPILATION, A BODY STUB MAY BE USED INSTEAD

```
procedure Subprogram_Name is separate;
```

THIS IMPLIES THAT THE ACTUAL BODY WILL BE SUPPLIED IN A SEPARATE SUBUNIT.

- THE SUBUNIT IS SUPPLIED WITH A PREFIX NAMING THE COMPILATION UNIT WHERE THE CORRESPONDING BODY STUB APPEARED

```
separate (Parent_Unit)        -- note no semicolon
procedure Subprogram_Name is -- body
```

- ALTHOUGH THE SUBUNIT IS SEPARATELY COMPILED THE EFFECT IS EXACTLY AS IF THE ACTUAL BODY WERE GIVEN AT THE POINT OF THE BODY STUB

INSTRUCTOR NOTES

ADA PROVIDES TWO MECHANISMS FOR PROGRAM DEVELOPMENT

- TOP-DOWN
  - LARGE COHERENT PROGRAM BROKEN DOWN INTO SEPARATELY-COMPILED SUBUNITS
  - SUBUNITS COMPILED AFTER UNIT ON WHICH THEY DEPEND
  - MECHANISM IMPLEMENTED USING "...is separate" AND "separate (...)" NOTATION
- BOTTOM-UP
  - TYPICAL APPLICATION IS A "LIBRARY" OF SUBPROGRAMS WRITTEN FOR GENERAL USE (PACKAGES)
  - THESE ARE WRITTEN AND COMPILED BEFORE UNITS THAT USE THEM
  - UNITS THAT DEPEND ON THEM GET ACCESS VIA with AND use CLAUSES

INSTRUCTOR NOTES

PROGRAM LIBRARY

- EVERY ADA PROGRAM HAS AN ASSOCIATED PROGRAM LIBRARY

- CERTAIN COMPILATION UNITS (PACKAGE DECLARATIONS, SUBPROGRAM DECLARATIONS, AND SUBPROGRAM BODIES WHEN THERE IS NO CORRESPONDING SUBPROGRAM DECLARATION) ARE LIBRARY UNITS

- AS LIBRARY UNITS ARE COMPILED, THEIR DECLARATIONS (NOT OBJECT CODE) GO INTO THE PROGRAM LIBRARY

- LIBRARY UNITS PROVIDE INTERFACE INFORMATION AND OTHER SPECIFICATION DATA NEEDED BY THE COMPILER TO PROCESS OTHER UNITS.

INSTRUCTOR NOTES

IF UNIT A MUST BE COMPILED BEFORE UNIT B, THEN IF A IS RECOMPILED B MUST BE RECOMPILED (UNLESS A SMART COMPILER CAN DETERMINE THAT ANY CHANGES MADE TO A DO NOT AFFECT B).

COMPILATION ORDER

AS A GENERAL RULE:

A GIVEN UNIT MUST BE COMPILED AFTER ANY UNITS CONTAINING INFORMATION UPON WHICH IT DEPENDS.

FOR EXAMPLE:

- A COMPILATION UNIT MUST BE COMPILED AFTER ALL LIBRARY UNITS NAMED BY ITS with CLAUSE
- A SUBPROGRAM OR PACKAGE BODY MUST BE COMPILED AFTER THE CORRESPONDING SUBPROGRAM OR PACKAGE SPECIFICATION
- A SUBUNIT MUST BE COMPILED AFTER ITS PARENT COMPILATION UNIT

INSTRUCTOR NOTES

UNDERLINE THE KEY PROGRAM UNITS OF THE EXAMPLE FOR SIMPLIFICATION.

SEPARATE COMPILATION EXAMPLE -- SUBUNITS

- SINGLE COMPILATION UNIT

```
with Text_IO;
procedure Top is
     type Real is digits 10;
     R, S : Real := 1.0;
     package Facility is
          Pi : constant := 3.14159_26536;
          function F (X : Real) return Real;
          procedure G (Y, Z : Real);
     end Facility;
     package body Facility is
          --  some local declarations followed by
          function F (X : Real) return Real is
          begin -- F
               --  sequence of statements of F
               ...
          end F;
          procedure G (Y, Z : Real) is
               --  local procedures using Text_IO
               ...
          begin -- G
               --  sequence of statements of G
               ...
          end G;
     end Facility;
     procedure Transform (U : in out Real) is
          use Facility;
     begin -- Transform
          U := F(U);
          ...
     end Transform;
begin -- Top
     Transform (R);
     ...
     Facility.G (R, S);
end Top;
```

INSTRUCTOR NOTES

SEPARATE COMPILATION EXAMPLE -- SUBUNITS (Continued)

- FOUR COMPILATION UNITS

```
          procedure Top is
                type Real is digits 10;
                R, S : Real := 1.0;

                package Facility is
                      Pi : constant := 3.14159_26536;
                      function F (X : Real) return Real;
1                     procedure G (Y, Z : Real);
                end Facility;

                package body Facility is separate;
                procedure Transform (U : in out Real) is separate;

          begin -- Top
                Transform (R);
                ...
                Facility.G (R, S);
          end Top;
------------------------------------------------------------------

          separate (Top)
          procedure Transform (U : in out Real) is
                use Facility;
2         begin -- Transform
                U := F (U);
                ...
          end Transform;

------------------------------------------------------------------
```

INSTRUCTOR NOTES

NOTE THAT THE LIBRARY UNIT Text_IO IS USED BY PROCEDURE 9 ONLY. BY USING STUBS WE CAN LOCALIZE THE AMOUNT INFORMATION IMPORTED.

SEPARATE COMPILATION EXAMPLE

FOUR COMPILATION UNITS (Continued)

```
         separate (Top)
         package body Facility is
                 -- some local declarations followed by
                 function F (X : Real) return Real is
3                begin -- F
                         --  sequence of statements of F
                         ...
                 end F;

                 procedure G (Y, Z : Real) is separate;
         end Facility;
--------------------------------------------------------------
         with Text_IO;
         separate (Top.Facility) -- full name of Facility
         procedure G (Y, Z : Real) is
                 --  local procedures using Text_IO
4                ...
         begin -- G
                 --  sequence of statements of G
         end G;
```

INSTRUCTOR NOTES

ARROWS INDICATE DIRECTION OF COMPILATION UNIT DEPENDENCIES.

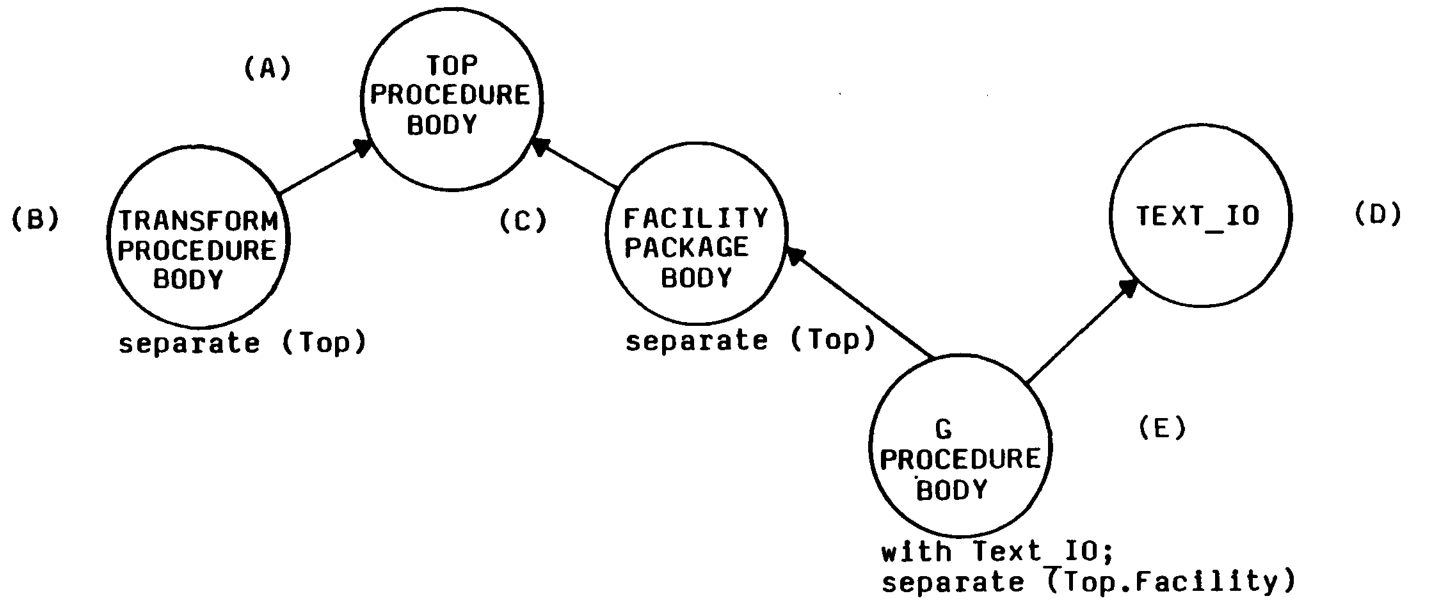
KEY POINTS:

1. SUBUNITS B, C CAN ONLY BE COMPILED AFTER THEIR PARENT UNIT A.

2. SINCE SUBUNIT B DOES NOT DEPEND ON C, SUBUNIT E CAN BE COMPILED BEFORE OR AFTER B.

3. IF Text_IO WERE NOT PRE-COMPILED, IT COULD BE COMPILED AT ANY TIME BEFORE E (SINCE E IS THE ONLY UNIT USING THE RESOURCE).

COMPILATION ORDER DEPENDENCIES



POSSIBLE COMPILATION ORDERS:

(A) (B) (C) (D) (E)
(A) (C) (B) (D) (E)
(A) (C) (D) (B) (E)
(A) (B) (D) (C) (E)
(A) (D) (B) (C) (E)
(A) (D) (C) (B) (E)
(A) (C) (D) (E) (B)
(A) (D) (C) (E) (B)

* (D) (A) (B) (C) (E)
(D) (A) (C) (B) (E)
(D) (A) (C) (E) (B)

*ACTUALLY, (d) -- Text_IO -- IS "PRE-COMPILED," SO THESE POSSIBILITIES DO NOT ARISE.

INSTRUCTOR NOTES

THIS IS INCLUDED FOR REFERENCE ONLY. DO NOT TALK THROUGH EXAMPLE.

SEPARATE COMPILATION EXAMPLE -- LIBRARY UNITS

- SINGLE COMPILATION UNIT

```
procedure Processor is

     Small : constant := 20;
     Total : Integer  := 0;

     package Stock is
            Limit : constant := 1000;
            Table : array (1 .. Limit) of Integer := (1 .. Limit => 0);
            procedure Restart;
     end Stock;

     package body Stock is
            procedure Restart is
            begin -- Restart
                   for N in Table'Range
                   loop
                          Table (N) := 0;
                   end loop;
            end Restart;
     end Stock;

     procedure Update (X : Integer) is
            use Stock;
     begin -- Update
            ...
            Table (X) := Table (X) + Small;
            ...
     end Update;
begin -- Processor
     ...
     Update (10);
     ...
     Stock.Restart; -- reinitializes Table
     ...
end Processor;
```

INSTRUCTOR NOTES

DON'T GO INTO GREAT DEPTH - AN EXERCISE ON COMPILATION ORDER FOLLOWS.

SEPARATE COMPILATION EXAMPLE -- LIBRARY UNITS (Continued)

- THREE COMPILATION UNITS

```
          package Stock is
                  Limit : constant := 1000;
1                 Table : array (1 .. Limit) of Integer := (1 .. Limit =  0);
                  procedure Restart;
          end Stock;
-----------------------------------------------------------------------------
          package body Stock is
                  procedure Restart is
                  begin -- Restart
                          for N in Table'Range
2                         loop
                                  Table(N) := 0;
                          end loop;
                  end Restart;
          end Stock;
-----------------------------------------------------------------------------
          with Stock;
          procedure Processor is
                  Small : constant := 20;
                  Total : Integer := 0;

                  procedure Update (X : Integer) is
                          use Stock;
                  begin -- Update
3                         ...
                          Table (X) := Table (X) + Small;
                          ...
                  end Update;
          begin -- Processor
                  ...
                  Update (10);
                  ...
                  Stock.Restart; -- reinitializes Table
                  ...
          end Processor;
```

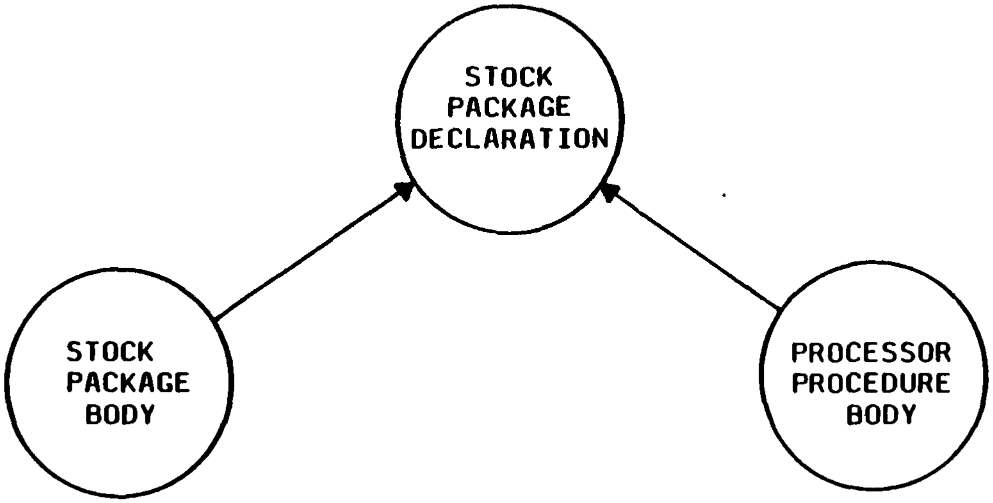
INSTRUCTOR NOTES

COMPILATION ORDER DEPENDENCIES

KEY POINTS:

1. STOCK PACKAGE DECLARATION MUST BE COMPILED BEFORE EITHER ITS BODY OR PROCESSOR.

2. PROCESSOR CAN BE COMPILED BEFORE STOCK PACKAGE BODY.



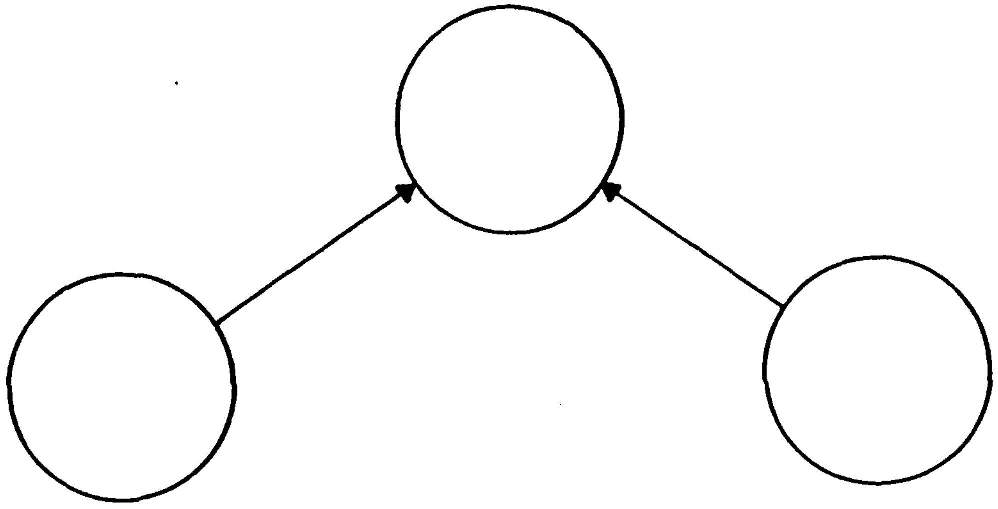
(with Stock;)

POSSIBLE COMPILATION ORDERS:

1. STOCK PACKAGE DECLARATION
2. STOCK PACKAGE BODY
3. PROCESSOR PROCEDURE BODY

1. STOCK PACKAGE DECLARATION
2. PROCESSOR PROCEDURE BODY
3. STOCK PACKAGE BODY

EXERCISE



POSSIBLE COMPILATION ORDERS:

1.

2.

3.

1.

2.

3.

INSTRUCTOR NOTES

RESUME DETAILED PRESENTATION HERE.

STUBBING TO INCREASE DESIGN UNDERSTANDABILITY, LOCALIZE LIBRARY UNIT (DATA) INFORMATION, AND DECREASE RECOMPILATION COSTS

ASSUME A PROCESSING PACKAGE WITH OTHER PROGRAM UNITS, WRITTEN BY DIFFERENT PROGRAMMERS, SPANNING 50 PAGES OF CODE.

<u>MAINTENANCE PROBLEMS</u>:

INTERACTIONS BETWEEN PROGRAM UNITS ARE DIFFICULT TO UNDERSTAND AND GLOBAL DATA REFERENCES MAY BE HARD TO TRACE.

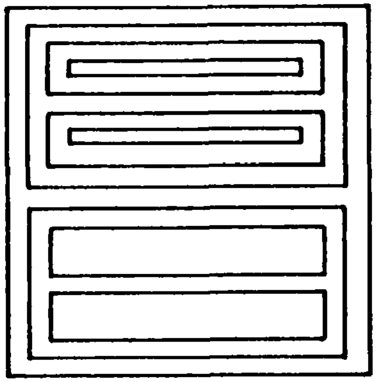
A ONE LINE CHANGE IN THE PACKAGE WOULD REQUIRE THE ENTIRE PACKAGE TO BE RECOMPILED (TIME, MONEY, RESOURCES).

DURING TESTING AND INTEGRATION, PROGRAMMERS COMPETE FOR ACCESS TO THE SOURCE CODE TO INCORPORATE NECESSARY REVISIONS. IF EACH HAS HIS OWN VERSION AND MAKES REVISIONS, CONFIGURATION MANAGEMENT PROBLEMS INCREASE.

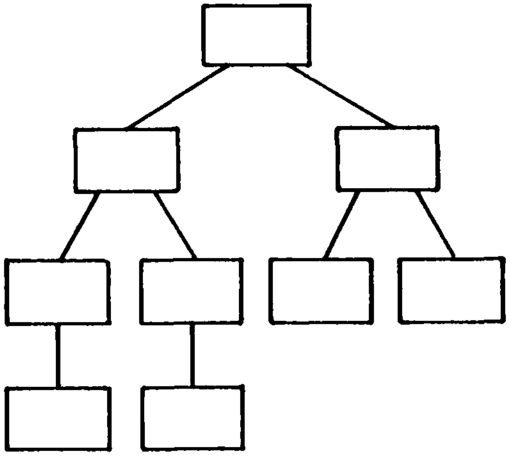
INSTRUCTOR NOTES

MODULE STRUCTURE

IF WE GRAPHICALLY REPRESENT A STRUCTURE, WHICH IS EASIER TO UNDERSTAND?



VS.



INSTRUCTOR NOTES

SIMILARITY,

WHICH IS EASIER TO UNDERSTAND IN A CODED SOLUTION ...

DON'T GO THROUGH EXAMPLE. JUST ASK THE CLASS, IF AT A QUICK GLANCE THEY UNDERSTAND ITS STRUCTURE. THEN PROCEED QUICKLY TO NEXT SLIDE.

THIS?

IN OUTLINE FORM, A PACKAGE BODY

```
with L1, L2;
package body P (written by programmer 1)
   task body T1 (written by programmer 1)
      variable declarations for T1
      function F1 (written by programmer 2)
         type and variable declarations for F1
         procedure P1 (written by programmers 2 and 3)
            variable declarations for P1
            statements for P1
         function F2 (written by programmer 2)
            subtype and variable declarations for F2
            statements for F2
         statements for F1
      statements for T1
   task body T2 (written by programmer 1)
      subtype declarations for T2
      statements for T2
   function F4 (written by programmer 1)
      subtype and object declarations for F4
      statements for F4
   task body T3 (written by programmers 2, 3 and 4)
      type and variable declarations for T3
end P;
```

INSTRUCTOR NOTES

THIS ILLUSTRATES THE INCREASED UNDERSTANDABILITY THROUGH USE OF STUBS. THE ESSENTIAL STRUCTURE IS EASILY SEEN HERE BUT WAS LOST IN THE PREVIOUS EXAMPLE.

OR THIS?

OUR PACKAGE USING STUBS ...

```
package body P is

   task body T1 is separate ;
   task body T2 is separate ;
   function F4 ( ... ) return ... is separate ;
   task body T3 is separate ;

end P ;
```

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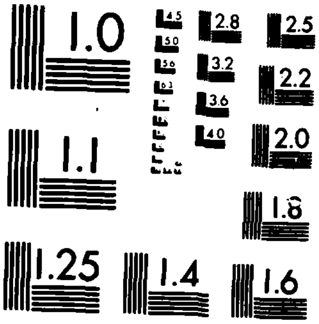


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

INSTRUCTOR NOTES

NOTE: THESE ARE JUST SOME OF THE SUBUNITS THAT WOULD RESULT -- JUST TO GIVE THE FLAVOR OF THE PROCESS.

IF A CHANGE IS NECESSARY TO ONE OF THE SUBUNITS, FOR EXAMPLE F1, ONLY F1 AND THE UNITS THAT ARE DEPENDENT ON F1, P1 AND F2 HERE, WOULD HAVE TO BE RECOMPILED -- NOT THE ENTIRE PACKAGE BODY.

"NECESSARY" LIBRARY UNITS WERE SELECTED ARBITRARILY.

... AND A LOOK AT SOME OF THE RESULTING SUBUNITS

```
separate (P)
task body T1 is
   [variable declaration for T1]
   function F1 ( ... ) return ... is separate ;
begin -- T1
   [statements for T1]
end T1;

-----------------------------------------------

with L2;    -- only the necessary library unit(s) are imported
separate (P.T1)
function F1 ( ... ) return ... is
   [type and variable declarations for F1]
   procedure P1 ( ... ) is separate;
   function F2 ( ... ) return ... is separate ;
begin -- F1
   [statements for F1]
end F1 ;

-----------------------------------------------

with L1;
separate (P.T1.F1)
procedure P1 ( ... ) is
   [variable declarations for P1]
begin -- P1
   [statements for P1]
end P1 ;
```

INSTRUCTOR NOTES

BOTH POINTS IMPORTANT TO STRESS: STUBBING IS NOT A CURE-ALL.

A FINAL NOTE

STUBBING IS A <u>TOOL</u> FOR MANAGING PHYSICAL COMPLEXITY; IF THE SUBUNITS HAVE INTRICATE MUTUAL INTERDEPENDENCIES, STUBBING DOES NOT, BY ITSELF, ELIMINATE THE COMPLEXITY.

INSTRUCTOR NOTE

MODULE LENGTH QUOTAS MAY BE IN TERMS OF PAGE LENGTH OR LINES OF CODE.

SOME POTENTIAL PITFALLS - STUBBING

- USING STUBBING TO SATISFY MODULE LENGTH QUOTAS MAY RESULT IN ILLOGICAL UNITS
- TOO TIGHT AN INTERCONNECTION WITH THE PARENT UNIT (PARENT AND STUB CANNOT BE UNDERSTOOD WITHOUT EACH OTHER)

INSTRUCTOR NOTES

Section 12
VISIBILITY AND SCOPE

INSTRUCTOR NOTES

MOTIVATION

- ALLOW DELIBERATE SHARING OF ENTITIES

  SMITH WRITES AN INITIALIZATION ROUTINE. BROWN WRITES A MEMORY DIAGNOSTIC ROUTINE. SMITH'S ROUTINE NEEDS TO CALL BROWN'S. THE NAME OF BROWN'S ROUTINE MUST BE "VISIBLE" TO SMITH'S ROUTINE.

INSTRUCTOR NOTES

MOTIVATION

- EVERY PROGRAMMER SHOULD BE ALLOWED TO INVENT NAMES FOR LOCAL ENTITIES WITHOUT ACCIDENTAL INTERFERENCE WITH ANOTHER PROGRAMMER'S WORK.

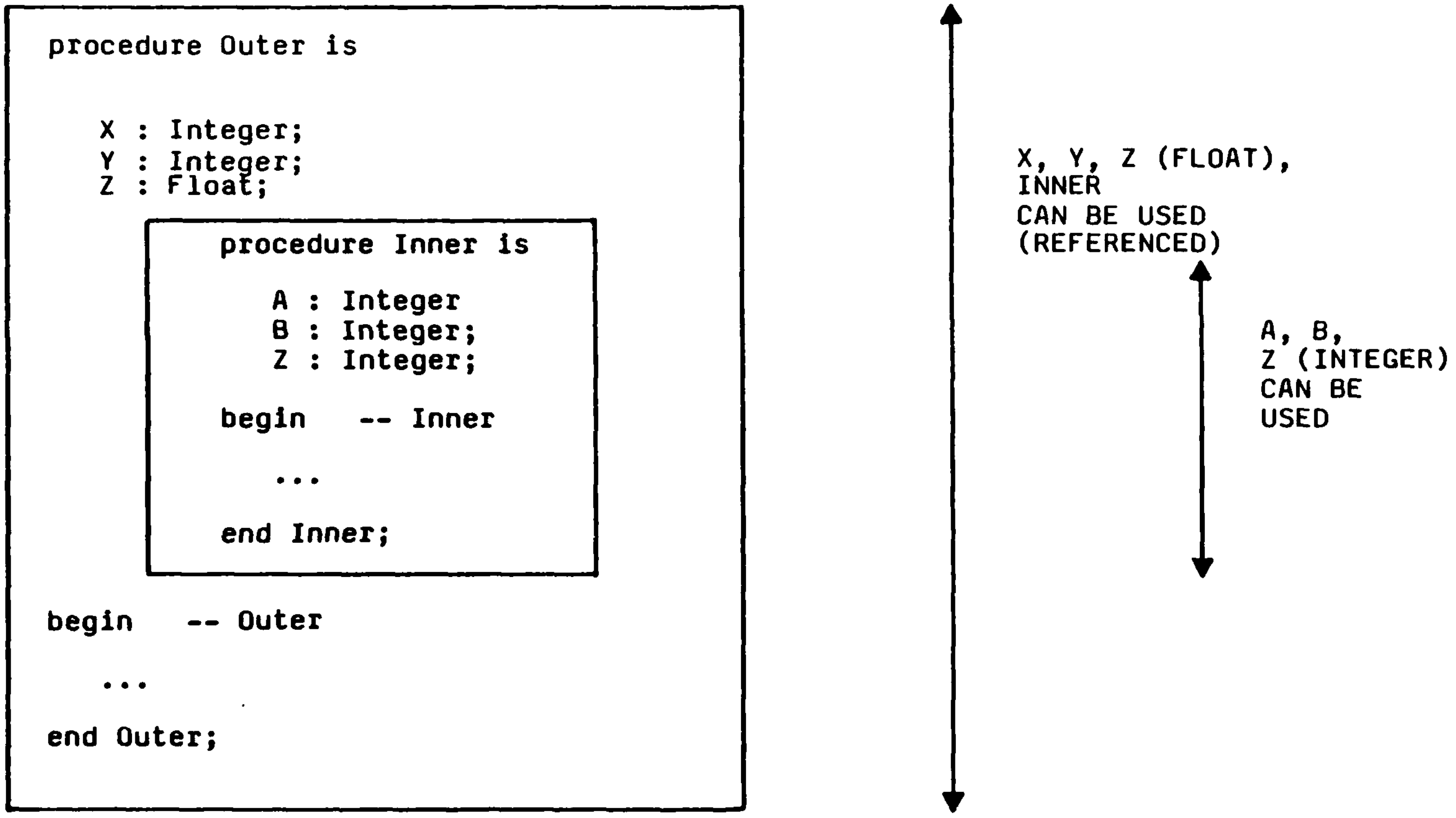
  BROWN CAN HAVE A LOCAL VARIABLE CALLED TEMP. SMITH CAN HAVE A LOCAL VARIABLE CALLED TEMP.

INSTRUCTOR NOTES

SCOPE = WHERE AN IDENTIFIER IS KNOWN AND CAN BE USED.

SCOPE

- AREA OF PROGRAM TEXT IN WHICH AN ENTITY APPLIES



```
procedure Outer is

   X : Integer;
   Y : Integer;
   Z : Float;

      procedure Inner is

         A : Integer
         B : Integer;
         Z : Integer;

      begin   -- Inner

         ...

      end Inner;

begin   -- Outer

   ...

end Outer;
```

X, Y, Z (FLOAT),
INNER
CAN BE USED
(REFERENCED)

A, B,
Z (INTEGER)
CAN BE
USED

INSTRUCTOR NOTES

VISIBILITY = WHERE AN IDENTIFIER IS KNOWN AND WHERE IT REFERS TO THAT ENTITY AND NOT TO SOMETHING ELSE.

WHEN WRITING/MODIFYING A PROGRAM UNIT P ...

... IF SOME ENTITY (E.G., A VARIABLE) X IS NOT VISIBLE ...

... THEN

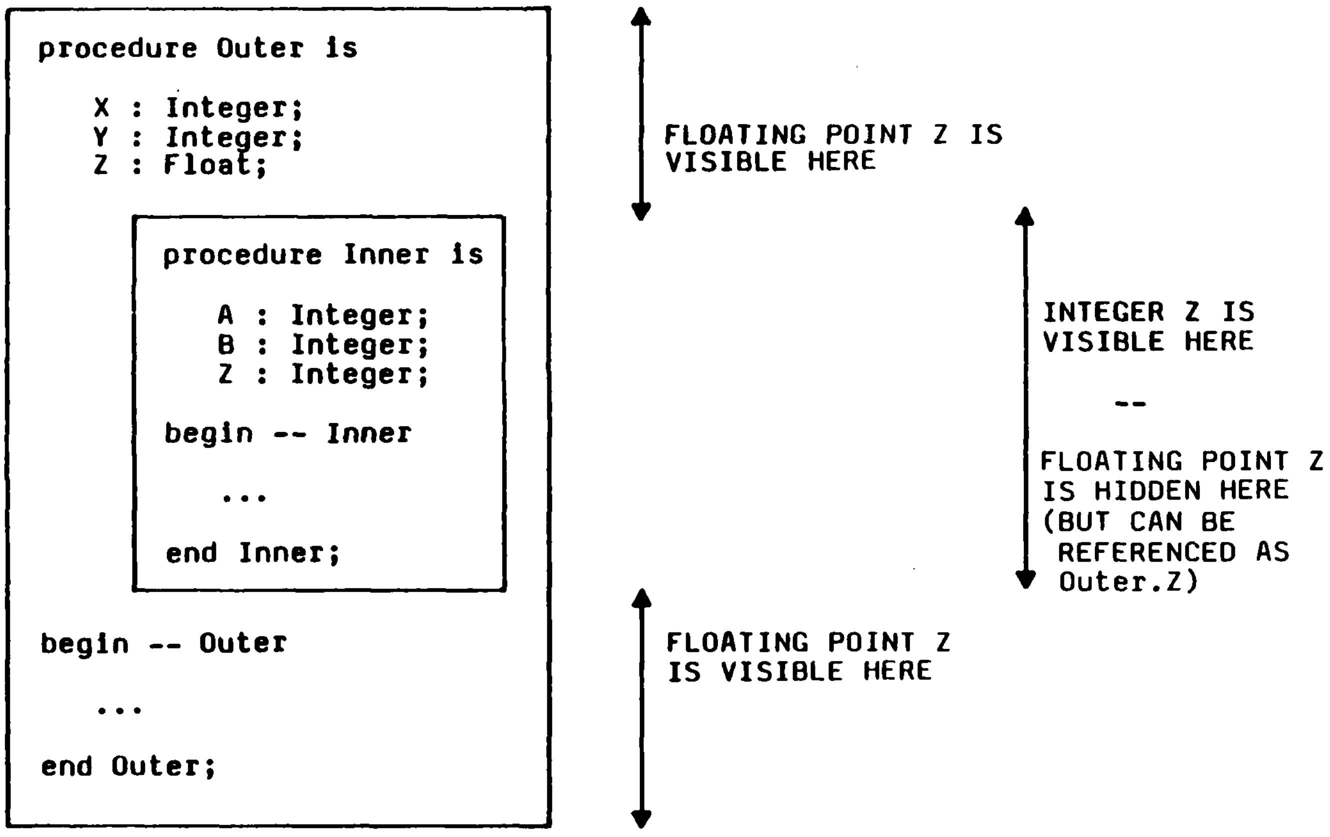
1. YOU CANNOT USE THAT VARIABLE IN ANY WAY IN P
2. YOU CAN FREELY USE THE NAME X FOR YOUR OWN DATA (OR SUBPROGRAM, ETC.)

... IN OTHER WORDS ...

WHERE SOMETHING IS NOT VISIBLE, FOR ALL PURPOSES IT DOESN'T EXIST.

VISIBILITY

- AREA OF PROGRAM TEXT IN WHICH AN ENTITY HAS A UNIQUE NAME



```
procedure Outer is

   X : Integer;
   Y : Integer;
   Z : Float;

      procedure Inner is

         A : Integer;
         B : Integer;
         Z : Integer;

      begin -- Inner

         ...

      end Inner;

begin -- Outer

   ...

end Outer;
```

FLOATING POINT Z IS VISIBLE HERE

INTEGER Z IS VISIBLE HERE

--

FLOATING POINT Z IS HIDDEN HERE (BUT CAN BE REFERENCED AS Outer.Z)

FLOATING POINT Z IS VISIBLE HERE

INSTRUCTOR NOTES

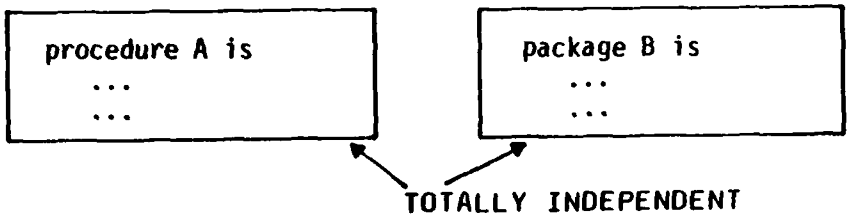
1. MEANS B DOESN'T SEE A AND VICE VERSA.

2. MEANS B CAN'T MENTION A BUT A CAN MENTION B.

GENERAL RULES
(INFORMALLY)

- LIBRARY UNITS

1. NOTHING IS MUTUALLY VISIBLE UNLESS EXPLICITLY REQUESTED

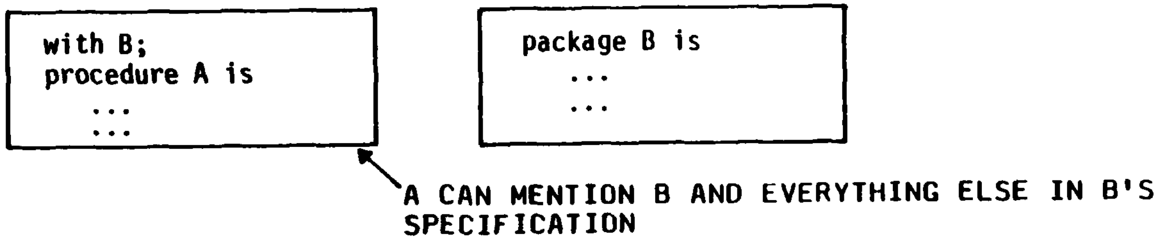


```
procedure A is
    ...
    ...
```

```
package B is
    ...
    ...
```

TOTALLY INDEPENDENT

2. THE with CLAUSE MAKES THE INTERFACE VISIBLE



```
with B;
procedure A is
    ...
    ...
```

```
package B is
    ...
    ...
```

A CAN MENTION B AND EVERYTHING ELSE IN B'S SPECIFICATION

3. ENTITIES DECLARED IN THE BODIES CAN NEVER BE MADE VISIBLE OUTSIDE OF THE BODY.

RATIONALE:

- MODULARITY WHILE AVOIDING ACCIDENTAL NAME CONFLICTS

INSTRUCTOR NOTES

POINT OUT THAT THE OUTERMOST UNIT IS EITHER A SUBPROGRAM, PACKAGE BODY OR TASK BODY.

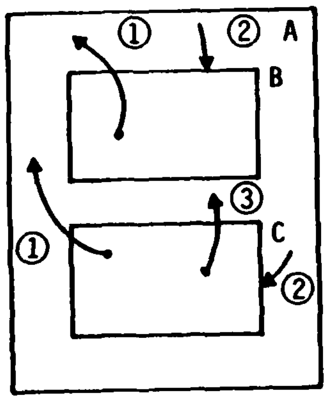
IF THE UNITS A, B AND C ARE ALL PACKAGE SPECS, THE RULES WOULD BE DIFFERENT:

1. STAYS SAME

2. WHAT'S DECLARED IN B IS VISIBLE BY SELECTION (I.E. B.entity) INSIDE C AND THE REST OF A BUT NOT VICE VERSA (C DECLARED AFTER B).

GENERAL VISIBILITY RULES (Continued)

- NESTED UNITS:



1. EVERYTHING DECLARED IN A IS VISIBLE FROM B AND C.

2. NOTHING DECLARED IN B OR C IS VISIBLE FROM A.

3. NOTHING DECLARED IN B IS VISIBLE FROM C, AND VICE-VERSA.

AN EASY RULE: YOU CAN LOOK OUT, BUT YOU CAN'T LOOK IN.

INSTRUCTOR NOTES

REMEMBER STUBS JUST TEXTUALLY REMOVE THE CODE TO ANOTHER AREA, BUT NOT LOGICALLY.

GENERAL VISIBILITY RULES (Continued)

- STUBS:

  AS FOR NESTED UNITS (STUBBING DOESN'T CHANGE VISIBILITY)

- IN ALL CASES:

  A LOCAL DECLARATION "HIDES" AN ENTITY WITH THE SAME NAME WHICH WAS VISIBLE FOR ANY OTHER REASON.

INSTRUCTOR NOTES

THESE HAVE BEEN VERY GENERAL GUIDELINES. IN REALITY ADA HAS VERY ELABORATE SCOPE AND VISIBILITY RULES.

SUMMARY

ADA HAS ELABORATE VISIBILITY RULES ...

... TO ALLOW PROGRAMMERS TO WORK INDEPENDENTLY ...

... EXCEPT WHEN THEY NEED TO COMMUNICATE.

INSTRUCTOR NOTES

SOME POTENTIAL PITFALLS - VISIBILITY

- ADA WAS DESIGNED SO THAT IF A PROGRAM IS LEGAL, IT MEANS WHAT YOU THINK IT DOES. BUT BECAUSE THESE RULES ARE COMPLEX, IT IS OCCASIONALLY DIFFICULT TO DIAGNOSE WHY A PROGRAM IS ILLEGAL.

- UNRESTRICTED USE OF THE use CLAUSE FOR PACKAGES MAKES PROGRAMS LESS SELF-DOCUMENTING AND HARDER TO UNDERSTAND. THE use CLAUSE MAKES ALL IDENTIFIERS DIRECTLY VISIBLE WITHOUT PREFIX (DOT) NOTATION. IF SEVERAL PACKAGES WITH MANY IDENTIFIERS ARE useED, IT BECOMES DIFFICULT TO KNOW WHERE TO FIND A GIVEN IDENTIFIER IF CHANGES ARE NECESSARY.

  RECOMMENDED USAGE:

  -- TO IMPORT STANDARD PACKAGES SUCH AS I/O

  -- TO BE ABLE TO USE IMPORTED OPERATORS IN "NATURAL" INFIX FORM
  X + Y RATHER THAN P. "+" (X, Y)

INSTRUCTOR NOTES

AS WE WILL SEE IN A MOMENT, THE USER CAN DEFINE THE MEANING OF ANY OPERATION FOR USER-DEFINED TYPES.

Section 13
OVERLOADING

INSTRUCTOR NOTES

EXAMPLES OF NAMES, SUBPROGRAMS OVERLOADED.

THE FIRST Put TAKES AN ARGUMENT OF TYPE STRING WHERE THE SECOND TAKES AN ARGUMENT OF Scores_Type. EACH Put IS A DISTINCT PROCEDURE, THEY JUST SHARE AN IDENTIFIER NAME.

OVERLOADING

- CONCEPT OF ONE ENTITY NAME REPRESENTING TWO OR MORE ENTITIES

```
Put ("Median of Scores is: ");
Put (Median);
```

- ENUMERATION LITERALS, SUBPROGRAM NAMES, OPERATORS CAN BE OVERLOADED

- ALLOWS PROGRAMMERS TO CHOOSE NAMES APPROPRIATE TO THEIR USE (THE ABSTRACTION) AS LONG AS AMBIGUITY CAN BE RESOLVED BY CONTEXT OR QUALIFICATION

INSTRUCTOR NOTES

USE OVERLOADING PURPOSEFULLY.

OVERLOADING

CAN BE USED

- TO SHOW SIMILARITY OF FUNCTION
- TO ALLOW THE USE OF "NATURAL" TERMINOLOGY WITHOUT NAME CONFLICTS

SHOULD BE USED WITH DELIBERATE INTENT

INSTRUCTOR NOTES

SUBPROGRAM OVERLOADING

- SUBPROGRAMS MAY BE OVERLOADED IF THEY HAVE DIFFERENT NUMBERS OR TYPES OF OPERANDS

- THE SUBPROGRAMS CAN THEN BE DISTINGUISHED BY THE PATTERN OF THEIR OPERANDS

- CONTEXT:

```
with Text_IO; use Text_IO;
        -- defines Put and Get for Strings
package Int_IO is new Integer_IO (Integer); use Int_IO;
        -- defines Put and Get for Integer
```

EXAMPLES:

```
Put ("NAME:"); -- uses Text_IO.Put
Put (3);  -- uses Int_IO.Put
```

INSTRUCTOR NOTES

GO THROUGH EXAMPLES, THEN ASK ...

IF WE HAD A STATEMENT LIKE

```
if Yes < No then ...
```

THE COMPILER DOESN'T KNOW WHICH TYPE THESE BELONG TO.

OVERLOADING - ENUMERATION LITERALS

SAME ENUMERATION LITERAL MAY BE USED IN MORE THAN ONE TYPE DECLARATION

```
type Counting_Format is (Binary, BCD);
type Tape_Format is (ASCII, EBCDIC, Binary);
type Interrupt_Status is (Yes, No);
type Answer is (Yes, No, Maybe);
```

INSTRUCTOR NOTES

ONE QUALIFIER NEEDED.

OVERLOADING:
TYPE AMBIGUITY AND QUALIFICATION

USUALLY THE COMPILER CAN SORT THINGS OUT. WHEN IN TROUBLE, ADA GIVES YOU A WAY OF UNIQUELY IDENTIFYING THE OVERLOADED LITERALS BY MEANS OF TYPE QUALIFICATION

Example:

```
        if Interrupt_Status'(Yes) < No then ...
```

IDENTIFYING NOTATION PRECEDES THE OVERLOADED LITERAL WITH ITS TYPE NAME AND AN APOSTROPHE.

SYNTAX:

```
Type_Name'(Overloaded_Literal)
```

INSTRUCTOR NOTES

OPERATOR OVERLOADING

- OPERATORS ARE IMPLEMENTED AS FUNCTIONS IN ADA. FOR EXAMPLE:

```
function "+" (Left, Right : Integer) return Integer;
function "+" (Left, Right : Float) return Float;
```

- OPERATORS ARE ALREADY OVERLOADED. IT IS POSSIBLE TO EXTEND OPERATORS TO OTHER DATA TYPES THROUGH OVERLOADING. FOR EXAMPLE:

```
function "+" (Left, Right : Matrix_Type) return Matrix_Type;
```

- FOR NOTATIONAL CONVENIENCE, INFIX NOTATION CAN BE USED. FOR EXAMPLE:

```
X := 1 + 2;           -- where X is type Integer
Y := 1.0 + 2.0;       -- where Y is type Float
A := M + N;           -- where M, N, A are of Matrix_Type
```

INSTRUCTOR NOTES

IF TWO SUBPROGRAMS PERFORM THE SAME ABSTRACT FUNCTION, WE CAN REFLECT THIS DIRECTLY IN ADA CODE.

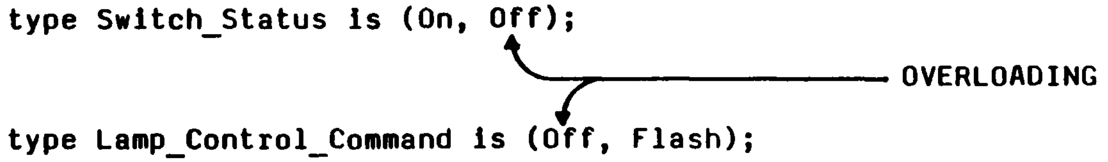
OVERLOADING TO SHOW FUNCTION SIMILARITY

```
procedure Get (Item : out Character);
procedure Get (Item : out Integer);

function "+" (A, B : in Matrix) return Matrix;
function "+" (A, B : in Vector) return Vector;
```

INSTRUCTOR NOTES

OVERLOADING TO ALLOW NATURAL NAMES



```
type Switch_Status is (On, Off);

type Lamp_Control_Command is (Off, Flash);
```

OVERLOADING

INSTRUCTOR NOTES

WE CAN DETERMINE THE SPECIFIC Sqrt FUNCTION THROUGH CONTEXT (I.E. THE TYPES OF THE PARAMETERS).

SOME POTENTIAL PITFALLS - OVERLOADING

- USING CONTRIVED IDENTIFIERS RATHER THAN OVERLOADING

  FOR EXAMPLE:

  ```
  function Float_Sqrt (X : Float) return Float;
  function Integer_Sqrt (X : Integer) return Float;
  ```

  BOTH FUNCTIONS SHOULD BE CALLED Sqrt.

- USING OPERATORS FOR FUNCTIONS NOT RELATED TO THEIR STANDARD MATHEMATICAL MEANINGS (E.G., USING UNARY "-" TO DENOTE MATRIX INVERSION)

INSTRUCTOR NOTES

BREEZE THROUGH THIS SECTION.

Section 14
PRAGMAS

INSTRUCTOR NOTES

PRAGMAS -- BASIC IDEA

- CONVEY INFORMATION TO THE COMPILER
- SOME ARE LANGUAGE-DEFINED
- OTHERS ARE IMPLEMENTATION-DEFINED
- MAY AFFECT PERFORMANCE OF PROGRAM
- DO NOT CHANGE MEANING OF PROGRAM (I.E., NO RESULTS PRODUCED)

INSTRUCTOR NOTES

EXAMPLE OF WHAT TO PRESENT IN SLIDE:

A. SYNTAX

B. FOR EXAMPLE:

1. PRAGMA INTERFACE ALLOWS MODULES WRITTEN IN OTHER LANGUAGES TO BE USED.

2. PRAGMA PACK IS A COMMAND FOR THE OPTIMAL SPACE ASSIGNMENT AND COMPRESSION OF DATA OBJECTS.

3. PRAGMA PAGE IS A COMMAND TO HAVE THE COMPILER LISTINGS FOR WHAT FOLLOWS TO START ON A NEW PAGE.

PREDEFINED PRAGMAS

SYNTAX:

```
pragma Predefined_Pragma_Name [(Parameters)];
```

WHERE Predefined_Pragma_Name CAN BE:

-- Controlled
-- Elaborate
-- Inline
-- Interface
-- List
-- Memory_Size
-- System_Name
-- Optimize
-- Pack
-- Page
-- Priority
-- Shared
-- Storage_Unit
-- Suppress

SUMMARIZED IN APPENDIX B OF LRM

INSTRUCTOR NOTES

EXAMPLES

```
pragma Page;
separate (Vector_Services)
procedure Sqrt (X : Float) is
   Epsilon : constant := 0.000001;
   Root : Float;
begin -- Sqrt
   ...
end Sqrt;
```

INSTRUCTOR NOTES

SOME POTENTIAL MISUSES - PRAGMAS

- POTENTIAL PORTABILITY PROBLEMS CAUSED BY IMPLEMENTATION-DEFINED PRAGMAS
- INLINE, OPTIMIZE, PACK: SHOULD BE USED WITH SOME CARE. THEY MAY ACTUALLY PRODUCE SLOW OR INEFFICIENT CODE.
- SHARED: REVEALS UNSYNCHRONIZED ACCESS TO DATA, WHICH IS EXTREMELY ERROR-PRONE.
- SUPPRESS: VERY DANGEROUS. SHOULD BE USED ONLY WHEN

  -- IT CAN BE PROVED THAT THE EXCEPTION WILL NEVER BE RAISED

  -- THE BENEFIT IN PERFORMANCE CAN BE DEMONSTRATED BY MEASUREMENTS

INSTRUCTOR NOTES

BREEZE THROUGH THIS SECTION. MANAGERS SHOULD KNOW THAT THESE FEATURES EXIST, THEIR USE SHOULD BE RESTRICTED TO ACTUAL NEED, SHOULD GROUP THESE FEATURES FOR EASE OF MAINTENANCE AND PORTING.

Section 15
LOW-LEVEL FEATURES

INSTRUCTOR NOTES

LOW-LEVEL FEATURES

NORMALLY IT IS SUFFICIENT TO ALLOW THE COMPILER TO MAKE THE CHOICES ON THE ACTUAL REPRESENTATION OF THE BIT PATTERNS AND HARDWARE ADDRESSING FOR PROGRAM ENTITIES (OBJECTS, PROGRAM UNITS, FOR EXAMPLE). WITH EMBEDDED SYSTEMS, IT BECOMES NECESSARY AT TIMES TO DEAL WITH THE ACTUAL HARDWARE ...

INSTRUCTOR NOTES

NOT EVERY PROGRAMMER WILL NEED TO USE THESE FEATURES. THEIR USE SHOULD BE THE EXCEPTION, NOT THE RULE.

LOW-LEVEL FEATURES

- FACILITIES TO INTERFACE WITH UNDERLYING HARDWARE OR PERIPHERALS WITHOUT LEAVING AN HOL
  - MACHINE REPRESENTATION SPECIFICATION
  - MACHINE CODE INSERTION
  - LOW-LEVEL I/O
  - UNCHECKED CONVERSION
- CAN BE USED FOR
  - MEMORY-MAPPED I/O
  - EXPLOITING UNDERLYING HARDWARE FEATURES

INSTRUCTOR NOTES

REPRESENTATION SPECIFICATIONS -- BASIC IDEA

- MAP ABSTRACT DATA TO PHYSICAL HARDWARE
- PHYSICAL REPRESENTATION OF VALUES
  - SPECIFY INTERNAL CODES FOR LITERALS OF AN ENUMERATION TYPE
  - SPECIFY RECORD LAYOUT
- CONTROL STORAGE
  - SPECIFY AMOUNT OF STORAGE ASSOCIATED WITH A TYPE
- CONTROL LOCATION
  - SPECIFY REQUIRED STORAGE ADDRESS FOR AN ENTITY

INSTRUCTOR NOTES

BASED NUMERIC LITERALS CAN BE USED ANYWHERE NUMERIC LITERALS OCCUR.

SYNTAX: BASE DECIMAL VALUE # NUMBER IN BASE NOTATION # ANY EXPONENTS

ENUMERATION TYPE REPRESENTATION CLAUSES

- MAPPING FROM ELEMENTS OF A TYPE TO SPECIFIC INTERNAL CODES

```
type Op_Codes is (LOD, STO, ADD, SUB, JNT);

for Op_Codes use (8#01#, 8#12#, 8#13#, 8#14#, 8#17#);
```

INSTRUCTOR NOTES

RECORD TYPE REPRESENTATION CLAUSES

- MAPS
  - ORDER OF RECORD COMPONENTS
  - COMPONENT POSITION
  - COMPONENT SIZE
  - GLOBAL ALIGNMENT OF RECORD

INSTRUCTOR NOTES

- MENTION THAT THE REPRESENTATION CLAUSE DOES NOT HAVE TO SPECIFY THE REPRESENTATION OF EACH COMPONENT. NOR DO THEY NEED TO SPECIFY THEM IN THE ORDER THEY APPEAR IN THE RECORD SPECIFICATION.

- POINT OUT THAT THE USE OF LOW LEVEL FEATURES IN PROGRAMS IS A MANAGEMENT ISSUE.

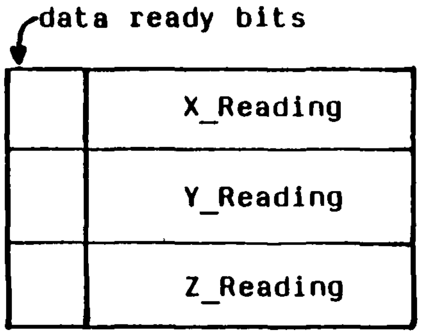
- at CLAUSE
    - LOCATES COMPONENT RELATIVE TO START OF RECORD
    - MEASURED IN STORAGE UNITS

- RANGE IN BITS
    - LOCATION AND EXTENT OF A COMPONENT RELATIVE TO A STORAGE_UNIT

- ALIGNMENT CLAUSE
    - STORAGE BOUNDARY FOR BEGINNING OF AN OBJECT

RECORD TYPE REPRESENTATION - EXAMPLE

```
type Position_Delta is range 0 .. 255;
type Gantry_Position_Reading is
       record
              X_Data_Ready : Boolean;
              X_Reading    : Position_Delta;
              Y_Data_Ready : Boolean;
              Y_Reading    : Position_Delta;
              Z_Data_Ready : Boolean;
              Z_Reading    : Position_Delta;
       end record;
```



```
for Gantry_Position_Reading use
       record at mod 2;      -- double byte boundary
              X_Data_Ready at 0 range 0..0;     -- word 0, bit 0
              X_Reading at 0 range 1..15;       -- word 0, bits 1-15
              Y_Data_Ready at 1 range 0..0;     -- etc.
              Y_Reading at 1 range 1..15;
              Z_Data_Ready at 2 range 0..0;
              Z_Reading at 2 range 1..15;
       end record;
```

INSTRUCTOR NOTES

LENGTH SPECIFICATION

- USED TO OVERRIDE THE AMOUNT OF STORAGE NORMALLY ASSOCIATED WITH AN ENTITY

- ATTRIBUTES
  - DATA TYPE

    T'Size : NUMBER OF BITS FOR OBJECTS OF TYPE T
  - ACCESS TYPE

    T'Storage_Size : NUMBER OF STORAGE UNITS TO BE RESERVED FOR ALLOCATING OBJECTS
  - TASK OR TASK TYPE

    T'Storage_Size : NUMBER OF STORAGE UNITS TO BE RESERVED FOR EACH ACTIVATION OF THE TASK OBJECT

-
  ```
  for Attribute use Integer_Expression;
  for Vehicle_Record'Size use 1000;
  ```

INSTRUCTOR NOTES

ADDRESS SPECIFICATION

- USED TO SPECIFY THE LOCATION OF AN OBJECT IN STORAGE

- USED TO SPECIFY THE STARTING ADDRESS OF A PROGRAM UNIT

```
for Boot_Program use at 8#40#;
```

- CAN BE USED TO ASSIGN AN ENTRY TO A HARDWARE INTERRUPT

```
task Fire_Control_Interrupt_Handler is
    entry Fired;
    for Fired use at 8#26#;
end Fire_Control_Interrupt_Handler;
```

INSTRUCTOR NOTES

MACHINE CODE INSERTIONS -- BASIC IDEA

- ADA PERMITS INSERTION OF MACHINE CODE INSTRUCTIONS, USING THE <u>CODE</u> STATEMENTS

- SPECIFICS ARE IMPLEMENTATION-DEPENDENT

- SHOULD BE USED ONLY FOR VERY SHORT SEQUENCES OF MACHINE LANGUAGE INSTRUCTIONS (1-5 INSTRUCTIONS). FOR LONGER SEQUENCES, WRITE AN ASSEMBLY LANGUAGE MODULE AND USE THE INTERFACE PRAGMA

- IN GENERAL, A VERY CLUMSY WAY OF WRITING MACHINE INSTRUCTIONS IN ADA

INSTRUCTOR NOTES

DON'T DWELL ON SLIDE.

LOW-LEVEL I/O

- INTERFACES TO A PHYSICAL DEVICE

- PREDEFINED PROCEDURES

  -- Send_Control : SENDS CONTROL INFORMATION TO A PHYSICAL DEVICE

  -- Receive_Control : MONITORS EXECUTION OF I/O BY REQUESTING INFORMATION FROM PHYSICAL DEVICE

- EACH PROCEDURE HAS TWO PARAMETERS

  -- Device : IDENTIFIES THE DEVICE

  -- Data : IDENTIFIES THE DATA

  TYPES OF PARAMETERS ARE IMPLEMENTATION DEFINED

- BODIES FOR THE PROCEDURES MAY BE WRITTEN IN CODE STATEMENTS

INSTRUCTOR NOTES

SUSPENDS ADA'S NORMAL TYPE CHECKING. AGAIN, FEATURE SHOULD BE USED SPARINGLY.

UNCHECKED CONVERSION

- USED FOR UNCHECKED TYPE CONVERSIONS (I.E. PERMITS CONVERSIONS BETWEEN <u>ANY</u> TWO TYPES)

- PROVIDED BY INSTANTIATION OF A GENERIC FUNCTION

```
generic
   type Source is limited private;
   type Target is limited private;
function Unchecked_Conversions (S : Source) return Target;
```

- RETURNS THE BIT PATTERN OF THE INPUT SOURCE

INSTRUCTOR NOTES

COVERAGE OF THE FOLLOWING (5 SLIDES) USING LOW-LEVEL FEATURES FOR MEMORY-MAPPED I/O IS OPTIONAL. IF COVERED, INSTRUCTOR SHOULD UNDERSTAND THE CODE, THE KEY POINTS STATED AS THE ADVANTAGES/DISADVANTAGES, AND THE CLASS SHOULD BE INTERESTED IN THE TOPIC. IF NOT COVERED, TELL THE CLASS FOR THOSE INTERESTED IN THIS PARTICULAR TOPIC, EXAMPLES ARE PROVIDED FOR FUTURE REFERENCE.

LOW-LEVEL FEATURES FOR MEMORY-MAPPED I/O

IN A COMPUTER SYSTEM, MEMORY_MAPPED I/O USES REGULAR MEMORY REFERENCE INSTRUCTIONS WHICH ARE MAPPED TO A DEVICE-SPECIFIC MEMORY ADDRESS OR I/O PORT. IN EMBEDDED COMPUTER SYSTEMS, THE ABILITY TO HAVE SPECIFIC DEVICE CONTROL IS VITALLY IMPORTANT.

AN EXAMPLE:

> TO BE ABLE TO READ AN 8-BIT VALUE FROM SOME MEMORY-MAPPED I/O DEVICE AND THEN TO WRITE AN 8-BIT VALUE TO THE DEVICE.
>
> SEVERAL POSSIBLE SOLUTIONS WILL BE SHOWN.

INSTRUCTOR NOTES

THE MAIN PROGRAM FOR EACH SOLUTION

```
procedure Main is
   subtype Byte is Integer range 0 .. 255;
   Vall, Val2 : Byte;

   procedure Device_IO (Outval : in Byte;
                        Inval  : out Byte) is separate;

begin  -- Main

   Vall := 41;                -- example value
   Device_IO (Vall, Val2);

end Main;
```

INSTRUCTOR NOTES

THE OBVIOUS SOLUTION

USE OF MACHINE REPRESENTATION FOR THE ADDRESS OF THE I/O PORT

```
separate (Main)
procedure Device_IO (Outval : in Byte;
                     Inval  : out Byte) is
   IO_Port     : Byte;                   -- The Memory_Mapped I/O port
   IO_Port_Loc : constant := 16#COFO#;   -- The address of the port

   for IO_Port use at IO_Port_Loc;       -- an address representation
                                         -- specification telling the
                                         -- compiler that the variable
                                         -- I/O_Port is to be located at
                                         -- address IO_Port_Loc
begin -- Device_IO

   IO_Port := Outval;  -- write outval to the IO_Port
   Inval   := IO_Port; -- read inval from the IO_Port

end Device_IO;
```

DISADVANTAGES:

IT WILL NOT WORK! FOR ORDINARY VARIABLES, THE SEQUENCE OF ASSIGNMENT STATEMENTS WOULD BE EQUIVALENT TO INVAL := OUTVAL. THE COMPILER WILL ALMOST CERTAINLY DO THE SIMPLIFICATION. THE VARIABLE FOR THE I/O PORT IS NOT AN ORDINARY VARIABLE AS THE VALUE RECEIVED FROM THE DEVICE WILL USUALLY BE CHANGED BY THE SYSTEM BEFORE IT IS EVER SENT BACK TO THE DEVICE THROUGH THE I/O PORT.

INSTRUCTOR NOTES

A WORKABLE SOLUTION

USING THE PRAGMA Shared INSURES THAT VARIABLES CONTAIN THEIR MOST CURRENT VALUE.

```
separate (Main)
procedure Device_IO (Outval : in Byte;
                     Inval  : out Byte) is
   IO_Port     : Byte;
   IO_Port_Loc : constant := 16#C0F0#;

   for IO_Port use at IO_Port_Loc;

   pragma Shared (IO_Port);

begin  -- Device_IO
   IO_Port := Outval;        -- write to IO_Port
   Inval := IO_Port;         -- read from IO_Port

end Device_IO;
```

DISADVANTAGES:

IT WILL BE HARD TO MAINTAIN WITHOUT EXPLICIT DOCUMENTATION TO DESCRIBE EXACTLY WHAT IS BEING DONE. FOR EXAMPLE, THE ASSIGNMENT STATEMENTS (IO_Port := Outval) ARE REALLY I/O OPERATIONS. THE CODE DOES NOT SHOW THIS ABSTRACTION.

INSTRUCTOR NOTES

Memory_Address_Type, Device_Type, AND Memory_Device ARE IMPLEMENTATION-DEFINED, NOT PART OF THE LRM SPECIFICATION FOR ADA.

A BETTER SOLUTION

USE THE STANDARD PACKAGE Low_Level_IO WHICH IS IMPLEMENTATION DEPENDENT

```
with Low_Level_IO;
separate (Main)
procedure Device_IO (Outval : in out Byte;
                     Inval  : in out Byte) is

   IO_Port_Loc : constant Low_Level_IO.Memory_Address_Type
                     := 16#C0F0#;
   IO_Port     : constant Low_Level_IO.Device_Type
                     := (Low_Level_IO.Memory_Device, IO_Port_Loc);

begin -- Device_IO
   Low_Level_IO.Send_Control (IO_Port, Outval);   -- write outval

   Low_Level_IO.Receive_Control (IO_Port, Inval); -- read inval

end Device_IO;
```

ADVANTAGES:

THE CODE MORE ACCURATELY STATES WHAT IS TO BE DONE.

INSTRUCTOR NOTES

RESUME COVERAGE HERE IF PREVIOUS EXAMPLE SKIPPED.

LOW-LEVEL FEATURES TO EXPLOIT BASIC HARDWARE

FOR EXAMPLE, REPRESENTATION SPECS TO ALIGN RECORDS ON WORD BOUNDARIES WHICH THEN ALLOW MORE EFFICIENT USE OF THE UNDERLYING MACHINE CODE.

IT SHOULD BE NOTED THAT USE OF THIS ADA FACILITY MAKES THE DESIGN HARDWARE SPECIFIC AND CONSEQUENTLY LIMITS PORTABILITY.

INSTRUCTOR NOTES

SOME POTENTIAL MISUSES - LOW-LEVEL FEATURES

- USED BECAUSE OF SIMILARITY TO ASSEMBLE LANGUAGE

- USED TO GAIN EFFICIENCY (RATHER THAN MORE THOUGHT, PLANNING, OR "TWIDDLING" WITH THE DESIGN)

- USED TO CIRCUMVENT ADA'S CONTROLLED TYPE CHECKING RULES

- LACK OF ENCAPSULATION

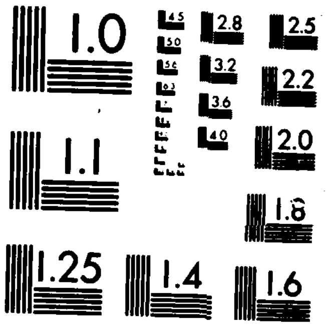
HINT: LOW-LEVEL FEATURES SHOULD BE USED TO IMPLEMENT SOME ABSTRACTION. HARDWARE CHARACTERISTICS (E.G., THE SPECIFIC FORMAT OF A CONTROL WORD) SHOULD BE HIDDEN INSIDE A PACKAGE THAT EXPORTS A LOGICAL VIEW (E.G., A RECORD TYPE DEFINITION)

INSTRUCTOR NOTES

THIS SECTION IS FOR STUDENT REFERENCE ONLY, NOT TO BE COVERED IN CLASS.

Section 16
SUMMARY OF USES OF ADA FEATURES

AD-A165 315   ADA (TRADEMARK) TRAINING CURRICULUM ADA (REGISTERED   4/5
TRADEMARK) FOR SOFTWARE MANAGERS L201 TEACHER'S GUIDE
VOLUME 2(U) SOFTECH INC WALTHAM MA 1986
UNCLASSIFIED   DAAB07-83-C-K506   F/G 5/9   NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

INSTRUCTOR NOTES

SUMMARY OF ADA FEATURES USES*

ADA FEATURE	USES
LEXICAL RULES	BUILDING BLOCKS OF ADA CODE FREE FORMAT FOR READABILITY/UNDERSTANDABILITY "NATURAL" IDENTIFIER NAME
ADA TYPING SYSTEM	CORRECT CLASS OF ERRORS BEFORE INTEGRATION DOCUMENT DESIGN EXPRESS DESIGN CONSTRAINTS
STATEMENTS	CONTROL FOR ALGORITHMS
PACKAGES	GROUP RELATED PROGRAM UNITS NAME COLLECTIONS OF DECLARATIONS EXPRESS ABSTRACT DATA OBJECTS EXPRESS FINITE STATE MACHINES
PRIVATE TYPES	CONTROL (BY USER) ABSTRACT DATA TYPES PASS GENERIC PARAMETERS

*USES LISTED ARE A REPRESENTATIVE SAMPLING OF APPROPRIATE USES. COMBINATIONS AND MODIFICATIONS WILL OCCUR.

INSTRUCTOR NOTES

SUMMARY (Continued)

ADA FEATURE	USES
SUBPROGRAMS	ARE MAIN PROGRAM UNITS DEFINITION OF ALGORITHM DEFINITION OF OPERATIONS ON ABSTRACT TYPE
TASKS	EXPRESS CONCURRENT ACTIONS CONTROL RESOURCES HANDLE INTERRUPTS ACT AS BUFFERS
GENERICS	WRITE TEMPLATE FOR MODULES WITH SIMILAR ALGORITHMS PASS TYPES OR SUBPROGRAMS TO PROGRAM UNITS DETAIL DESIGN DECISIONS WHILE DEFERRING DESIGN DECISIONS
EXCEPTIONS	DETECT AND RECOVER FROM EXCEPTIONAL OR ERROR CONDITIONS DO "CLEANUP" ACTIONS FOR HARDWARE MALFUNCTIONS
STUBS	COMPLEX CODE UNDERSTANDABILITY LOCALIZE LIBRARY UNIT INFORMATION DECREASE RECOMPILATION

INSTRUCTOR NOTES

SUMMARY (Continued)

ADA FEATURE	USES
VISIBILITY	PREVENTS ACCIDENTAL NAME CONFLICTS ALLOWS DELIBERATE SHARING OF NAMES ALLOWS PROGRAMMERS TO WORK INDEPENDENTLY
OVERLOADING	SHOW SIMILARITY OF FUNCTION ALLOW NATURAL NAMES
INPUT/OUTPUT	ALLOWS USER COMPLETE CONTROL OF I/O ALLOWS CREATION OF INTERFACES WITH NON-STANDARD I/O DEVICES
PRAGMAS	PERMIT COMMANDS (SPECIAL REQUESTS) TO THE COMPILER
LOW LEVEL FEATURES	DO MEMORY-MAPPED I/O EXPLOIT UNDERLYING HARDWARE

INSTRUCTOR NOTES

Section 17

INTRODUCTION TO ADA DESIGN/CODE ASSESSMENT

INSTRUCTOR NOTES

ADA FOR SOFTWARE MANAGERS

INTRODUCTION
(Section 1)

ADA FEATURES
(Section 2-16)

INTRODUCTION TO ADA DESIGN/CODE ASSESSMENT
(Section 17)

CHARACTERISTICS OF GOOD ADA DESIGNS
(Section 18)

ADA IN PERSPECTIVE: REUSABILITY AND PORTABILITY
(SECTION 19)

INSTRUCTOR NOTES

ALLOW 2-2 1/2 HOURS FOR ENTIRE EXERCISE. DON'T RUSH IT TO MAKE UP TIME.

BREAK CLASS UP INTO GROUPS OF 3 OR 4. IN GROUPING THE STUDENTS, BE SURE ITS GROUP HAS AT LEAST ONE SHARP STUDENT (TO BE SURE EACH GROUP IS ABLE TO DO THE EXERCISE).

PASS OUT THE SEPARATE HANDOUT WITH SOLUTION 1. TELL THE GROUPS THAT THE HANDOUT IS THE SAME CODE AS IN THE COURSE NOTES BUT IS A MORE MANAGEABLE FORM. THEY CAN MAKE ANY NOTES THE WISH ON IT. INSTRUCT THE GROUPS THAT THEY ARE TO LOOK AT THE CODE AND AS A GROUP NOTE THEIR COMMENTS. (THE SOLUTION DOES SOLVE THE PROBLEM. WE WANT TO LOOK AT HOW IT DOES IT). TELL THE STUDENTS THEY HAVE 45-60 MINUTES FOR PART 1.

WHEN THE CLASS REASSEMBLES, HAVE EACH GROUP INFORMALLY PRESENT THEIR COMMENTS. INSTRUCTOR SHOULD MAKE A LIST OF THESE. IF MOST OF THE KEY POINTS HAVE NOT BEEN ADDRESSED BY THE CLASS, ADD THEM TO THE LIST (BUT PRESENT THEM IN THE FORM OF A QUESTION). ALLOW 15-30 MINUTES FOR DISCUSSION OF SOLUTION 1. THEN HAND OUT THE ALTERNATE SOLUTION. HAVE THE CLASS GO BACK TO THEIR GROUPS AND SPEND 30-45 MINUTES LOOKING AT THIS VERSION, KEEPING IN MIND THE ISSUES RAISED FROM SOLUTION 1. REASSEMBLE, HAVE GROUPS PRESENT, KEEPING A LIST OF THEIR COMMENTS. SUMMARIZE BY SHOWING HOW THE ALTERNATE SOLUTION COMMENTS ADDRESSED THE DEFICIENCIES NOTED FOR SOLUTION 1. ALLOW 10-20 MINUTES.

STUDENT PROBLEM

ASSESS A DESIGN.

THE TELEPHONE DIRECTORY SYSTEM ALLOWS THE USER TO LOOK UP NAMES, ADD NEW NAMES AND PHONE NUMBERS TO THE DIRECTORY, DELETE NAMES FROM THE DIRECTORY, AND EXIT THE SYSTEM.

INSTRUCTOR NOTES

WHAT HAPPENS WHEN THE SYSTEM USER ENTERS AN INCORRECT COMMAND? FROM OUR MAIN PROGRAM, HOW IS THE DIRECTORY INITIALIZED?

CAN WE TELL FROM THE MAIN PROGRAM HOW THE SYSTEM IS ORGANIZED AND OPERATES?

HOW DOES THE USER TERMINATE AND EXIT THE SYSTEM (I.E. HOW DOES MAIN PROCEDURE END)?

WHAT HAPPENS IF THE USER DOESN'T ENTER A VALID COMMAND?

SOLUTION 1

```
with Text_IO, Dir_Mgr;
use Text_IO;
procedure Directory is

     Command : Character;
     Done : Boolean := False;
     procedure Process (Command : in     Character;
                        Done    : in out Boolean) is separate;

begin   -- Directory

     New_Page;   -- clear screen
     Put_Line ("Telephone Directory System");

     loop
          Put ("Enter Command (L: Lookup, " &
               "A: Add, D: Delete, Q: Quit): ");
          Get (Command);
          New_Line;
          Process (Command, Done);

     exit when Done;   -- when Q is entered

     end loop;

end Directory;
```

INSTRUCTOR NOTES

IF WE NEED TO CHANGE THE DATABASE FORMAT, WHAT HAPPENS TO PROCESS?

HOW EASY IS IT TO ADD ANOTHER COMMAND OR TAKE ONE AWAY? WHAT WILL HAVE TO BE CHANGED? (HINT: WE WOULD HAVE TO CHANGE EXECUTABLE CODE).

HOW EASY WOULD IT BE TO CHANGE OUR DATABASE?

THROUGHOUT HOW WELL DOES AN ENTITY'S NAME REFLECT WHAT IT DOES OR WHAT IT REPRESENTS?

SOLUTION 1 (Continued)

```
separate (Directory)
procedure Process (Command : in Character;
                   Done    : in out Boolean) is
     Name          : Dir_Mgr.Name_String;
     Telno         : Dir_Mgr.Telno_String;
     Present, Room : Boolean := False;

     procedure Get_String (Str : out String) is separate;

begin   -- Process

     case Command is
          when 'L' |'l' =>   -- look up
               New_Line;
               Put ("Name : ");
               Get_String (Name);     -- Get name to look up
               Dir_Mgr.Lookup (Name, Telno, Present);
               if not Present
               then
                    Put_Line ("Name not found.");
               else
                    Put ("Number is");     -- print the telephone number
                    Put_Line (Telno);
               end if;
```

INSTRUCTOR NOTES

IF WE MUST CHANGE THE USER I/O INTERFACE, WHAT AND WHERE ARE CHANGES NECESSARY?

IF WE CHANGE THE SUBPROGRAM PARAMETERS, WHAT AND WHERE WILL CHANGES BE NECESSARY?

IS THIS HOW WE MIGHT SOLVE THE PROBLEM IF WE WERE CODING IN FORTRAN OR PASCAL? (YES!)

SOLUTION 1 (Continued)

```
           when 'A' | 'a' =>              -- Add
                Put ("Name : ");
                Get_String (Name);      -- Get Name
                New_Line;
                Put ("Number : ");      -- And Number to Add
                Get_String (Telno);
                Dir_Mgr.Insert (Name, Telno, Present, Room);
                if Present
                then
                     Put_Line ("Name already present.");
                elsif not Room
                then
                     Put_Line ("Directory full.");
                else
                     Put_Line ("Name added.");
                end if;
           when 'D' | 'd' =>   -- Delete
                Put ("Name :");
                Get_String (Name);      -- Get Name to Delete
                Dir_Mgr.Delete (Name, Present);
                if not Present
                then
                     Put_Line ("Name not present.");
                else
                     Put_Line ("Name deleted.");
                end if;
           when 'Q' | 'q' =>
                Done := True;
           when others =>
               Put_Line ("Invalid command.");
      end case;
end Process;
```

INSTRUCTOR NOTES

WHAT HAPPENS IF THE DIRECTORY IS FULL OR YOU TRY TO ADD A NAME THAT IS ALREADY IN THE DIRECTORY?

SOLUTION 1 (Continued)

```
package Dir_Mgr is

     Name_String_Size  : constant := 20;
     Telno_String_Size : constant := 12;

     subtype Name_String  is String (1 .. Name_String_Size);
     subtype Telno_String is String (1 .. Telno_String_Size);

     procedure Lookup (Name    : in  Name_String;
                       Telno   : out Telno_String;
                       Present : in out Boolean);

     procedure Insert (Name    : in  Name_String;
                       Telno   : in  Telno_String;
                       Present : in out Boolean;
                       Room    : in out Boolean);

     procedure Delete (Name    : in Name_String;
                       Present : in out Boolean);
end Dir_Mgr;
```

INSTRUCTOR NOTES

SOLUTION 1 (Continued)

```
package body Dir_Mgr is

     type Dir_Entry is
          record
               Name  : Name_String;
               Telno : Telno_String;
          end record;

     Size : constant := 100;
     subtype Index_Type is Integer range 0 .. Size;
     type Directory_Type is array (1 .. Index_Type'Last) of Dir_Entry;
     Directory : Directory_Type;
     Length: Index_Type;
     -- the code for the two procedures following are not included

     procedure Get_Directory (Directory : in out Directory_Type;
                              Index     : out    Index_Type) is separate;

     procedure Save_Directory is separate;
```

INSTRUCTOR NOTES

SOLUTION 1 (Continued)

```
procedure Find (Name_To_Find   : in  Name_String;
                Entry_Location : out Index_Type;
                Present        : in out Boolean) is
     Found: Boolean := false;
begin  -- Find
     Entry_Location := 0;
     for Position in 1 .. Length
     loop  -- thru Directory looking for Name_To_Find
          Present := Directory (Position).Name =
                          Name_To_Find;
          if Present
          then
               Entry_Location := Position;    -- return INDEX Location
               exit;
          end if;
     end loop;
end Find;

procedure Lookup (Name    : in  Name_String;
                  Telno   : out Telno_String;
                  Present : in out Boolean) is
     Entry_Location : Index_Type;
begin   -- Lookup
     Find (Name, Entry_Location, Present);
     if Present
     then
          Telno := Directory (Entry_Location).Telno;   -- return telephone
                                                       -- number associated
                                                       -- name
     end if;
end Lookup;
```

WHAT HAPPENS IF DIRECTORY IS EMPTY?

SOLUTION 1 (Continued)

```
    procedure Insert (Name    : in  Name_String;
                      Telno   : in  Telno_String;
                      Present : in out Boolean;
                      Room    : in out Boolean) is
        Entry_Location : Index_Type;
    begin   -- Insert
        Room := False;
        Find (Name, Entry_Location, Present);
        if not Present
        then
            Room := Length < Size;    -- check to see if room exists for
                                      -- additional entry
            if Room
            then   -- add entry
                Length := Length + 1;
                Directory(Length).Name := Name;
                Directory(Length).Telno := Telno;
            end if;
        end if;
        Save_directory;
    end Insert;

    procedure Delete (Name    : in  Name_String;
                      Present : in out Boolean) is
        Entry_Location : Index_Type;
    begin   -- Delete
        Find (Name, Entry_Location, Present);
        if Present
        then   -- Delete entry and close gap
            for Ent_Num in Entry_Location .. Length - 1
            loop
                Directory (Ent_Num) := Directory (Ent_Num + 1);
            end loop;
            Length := Length - 1;
        end if;
        Save_Directory;
    end Delete;

begin   -- Dir_Mgr
    Get_Directory (Directory, Length);  -- Initialize Directory
end Dir_Mgr;
```

OVERALL, DID OBJECT NAMES (INCLUDING PROGRAM UNITS) ACCURATELY REFLECT THEIR FUNCTION?

SOLUTION 1 (Continued)

```
separate (Directory.Process)
procedure Get_String (Str : out String) is
     Last : Natural;
begin   -- Get_String
     Get_Line (Str, Last);        -- get input
     Str (Last+1 .. Str'Last) := (Last+1 .. Str'Last =>' '); -- blank fill
     if not End_Of_Line
     then
          Skip_Line;              -- ignore extra characters
     end if;
end Get_String;
```

INSTRUCTOR NOTES

PROGRAM UNITS HAVE BEEN RENAMED TO REFLECT THEIR FUNCTIONS. MAIN PROGRAM SHOWS THE ENTIRE SYSTEM AT A GLANCE; FOR THE DETAILS WE CAN LOOK AT THE RESPECTIVE PACKAGES. THE MAIN PROGRAM COORDINATES I/O INTERFACE AND ROUTES REQUEST FOR NECESSARY PROCESSING.

GETTING AND SAVING THE DIRECTORY ARE DONE WITHIN THE MAIN PROGRAM FOR SYMMETRY. (WE CAN "GET" THE DIRECTORY FROM WITHIN THE PACKAGE, BUT WE CANNOT "SAVE" THE DIRECTORY IN THE SAME PLACE. ADA REQUIRES EXPLICIT TESTING AND CLOSING OF FILES.)

AN ALTERNATE VERSION OF
THE DIRECTORY SYSTEM

```
with Text_IO; use Text_IO;
with Directory_Services; use Directory_Services;

procedure Directory_Manager is
     type Request_State is (Lookup, Add, Delete, Quit);
     Name : Name_Type;
     Telephone_Number : Telephone_Number_Type;
     Request : Request_State;

     procedure Get_Input_Request (Name             : out Name_Type;
                                  Telephone_Number : out Telephone_Number_Type;
                                  Request          : out Request_State)
                                                     is separate;
begin -- Directory_Manager
     Get_Directory;
     loop
          begin
               Get_Input_Request (Name, Telephone_Number, Request);
               case Request is
                    when Lookup  => Lookup_Entry (Name, Telephone_Number);
                                    Put ("Telephone number is ");
                                    Put_Line (Telephone_Number);
                    when Add     => Insert_Entry (Name, Telephone_Number);
                                    Put_Line ("Name added");
                    when Delete  => Delete_Entry (Name);
                                    Put_Line ("Name deleted");
                    when Quit    => exit;
               end case;
          exception
               when Name_Not_In_Database  =>  Put_Line ("Name not found");
               when Directory_Full        =>  Put_Line ("Directory full");
          end;
     end loop;
     Save_Directory;
exception
     when Read_Error  =>  Put_Line ("Cannot read directory file");
     when Write_Error =>  Put_Line ("Cannot save directory file");
end Directory_Manager;
```

INSTRUCTOR NOTES

ALL USER INTERFACE IS LOCALIZED.

IF INCORRECT COMMANDS ARE ENTERED, THE USER IS PROMPTED AND ALLOWED TO TRY AGAIN (SELF-CHECKING I/O).

THIS SAME SEQUENCE OF CODE CAN BE USED FOR ANY COMMAND; THUS WE DON'T HAVE TO REPEAT THE SAME I/O COMMAND FOR EACH REQUEST FUNCTION.

ALTERNATE (Continued)

```
separate (Directory_Manager)
procedure Get_Input_Request (Name             : out Name_Type;
                             Telephone_Number : out Telephone_Number_Type;
                             Request          : out Request_State) is

   package Command_IO is new Text_IO.Enumeration_IO (Request_State);
   use Command_IO;
   procedure Get_Name (Name : out Name_Type) is separate;
   procedure Get_Number (Telephone_Number : out Telephone_Number_Type)
                        is separate;
begin -- Get_Input_Request
   loop
      begin
         -- Enter prompt and read command
         New_Line;
         Put ("Enter Command (Lookup, Add, Delete, Quit):");
         Get (Request);
         New_Line;

         -- Get input from user
         case Request is
            when Add =>  Get_Name(Name); Get_Number (Telephone_Number);
            when Lookup | Delete  =>  Get_Name  (Name);
            when Quit =>  exit;
         end case;
      exception
         -- To handle user keying errors
         when Data_Error =>  Put ("Invalid command, try again");
      end;

   end loop;

end Get_Input_Request;
```

INSTRUCTOR NOTES

ALL DIRECTORY SERVICES ARE COLLECTED TOGETHER WITH NO EXTRANEOUS DECLARATIONS.

NAME CHANGE OF PROGRAM UNIT TO REFLECT ITS PURPOSE. NAMES OF ENTITIES, IN GENERAL ARE BETTER.

ALTERNATE (Continued)

```
package Directory_Services is

   -- Types used in user interfaces
   subtype Name_Type is String (1 .. 20);
   subtype Telephone_Number_Type is String (1 .. 15);

   -- Primary operations allowed
   procedure Lookup_Entry (Name             : in Name_Type;
                           Telephone_Number : out Telephone_Number_Type);
   procedure Insert_Entry (Name             : in Name_Type;
                           Telephone_Number : in Telephone_Number_Type);
   procedure Delete_Entry (Name             : in Name_Type);

   -- Database service operations
   procedure Get_Directory;
   procedure Save_Directory;

   -- Exceptional conditions
   Name_Not_In_Database : exception;
   Directory_Full       : exception;
   Read_Error           : exception;
   Write_Error          : exception;

end Directory_Services;
```

INSTRUCTOR NOTES

ALL DECLARATIONS RELATED TO THE DATABASE ARE FOUND IN ONE PACKAGE. THE DATABASE IS IMPLEMENTED AS AN ABSTRACT OBJECT. THE OPERATIONS ON THE TYPE MUST BE PROVIDED AT THE SAME TIME.

THE REST OF THE SYSTEM IS NOT AS DEPENDENT ON OUR ENTRIES BEING OF STRING FORMAT.

IF WE NEED TO CHANGE THE LENGTH OF THE ENTRIES OF THE DATABASE WE KNOW EXACTLY WHERE TO GO AND THEN THE REST OF THE SYSTEM WILL NOT NEED MODIFICATION.

ALTERNATE (Continued)

```
package body Directory_Services is

   type Directory_Entry is
      record
         Name             : Name_Type;
         Telephone_Number : Telephone_Number_Type;
      end record;
   subtype Index is Integer range 0 .. 100;
   type Directory_Type is array (1 .. Index'Last) of Directory_Entry;
   Directory : Directory_Type;
   Current_Database_Length : Index := 0;

-----------------------------------------------------------------------------

   procedure Find_Entry (Name_To_Find        : in Name_Type;
                         Entry_Location      : out Index;
                         Present_In_Database : out Boolean) is
   begin -- Find_Entry
      Present_In_Database := False;
      for Position in 1 .. Current_Database_Length loop
         if Directory(Position).Name = Name_To_Find then
            Present_In_Database := True;
            Entry_Location := Position;
            exit;
         end if;
      end loop;
   end Find_Entry;

-----------------------------------------------------------------------------
```

INSTRUCTOR NOTES

SINCE "FIND" IS USED BY THREE OF THE SERVICES IT SEEMED REASONABLE TO DEFINE IT WITHIN THE SAME PHYSICAL STRUCTURE BUT THAT IT WOULD BE CLEARER IF THE SERVICES WERE SUBUNITS.

CODE FOR FIND IS CLEANER, MORE ADA-LIKE IN STYLE.

ALTERNATE (Continued)

```
   procedure Lookup_Entry  (Name              : in Name_Type;
                            Telephone Number : out Telephone_Number_Type)
                            is separate;
   procedure Insert_Entry  (Name              : in Name_Type;
                            Telephone number : in Telephone_Number_Type)
                            is separate;
   procedure Delete_Entry  (Name              : in Name_Type) is separate;
   procedure Get_Directory is separate;
   procedure Save_Directory is separate;

end Directory_Services;
```

INSTRUCTOR NOTES

EACH OF THE REQUEST FUNCTION PROCEDURES BECOMES VERY SIMPLE AND STRAIGHTFORWARD.

IF CHANGES NEED TO BE MADE TO ANY OF THEM, IT IS EASIER TO FIND THAN BEFORE WITH A LARGE CASE STATEMENT. (IT IS TOO EASY NOT TO SEE PART OF THE CODE RELEVANT TO A PARTICULAR CASE OPTION OR TO MODIFY CODE THAT REALLY BELONGS TO ANOTHER OPTION.)

ALTERNATE (Continued)

```
separate (Directory_Services)

procedure Lookup_Entry (Name             : in Name_Type);
                        Telephone_Number : out Telephone_Number_Type) is

   Entry_Location : Index;
   Entry_Found    : Boolean;

begin -- Lookup_Entry

   Find_Entry (Name, Entry_Location, Entry_Found);
   if Entry_Found then
      Telephone_Number := Directory(Entry_Location).Telephone_Number;
   else
      raise Name_Not_In_Database;
   end if;

end Lookup_Entry;
```

INSTRUCTOR NOTES

NOTE EASE OF ASSIGNMENT STATEMENT (I.E., REFLECTS A NATURAL SOLUTION STYLE).

NESTED IF STRUCTURE IS COMPLEX. AN ELSIF IS APPROPRIATE.

INSERT IS BEING USED TO PERFORM MORE THAN ONE FUNCTION. WE MIGHT WANT ANOTHER COMMAND TO CHANGE AN EXISTING ENTRY.

ALTERNATE (Continued)

```
separate (Directory_Services)

procedure Insert_Entry (Name             : in Name_Type);
                        Telephone_Number : in Telephone_Number_Type) is

   Entry_Location : Index;
   Entry_Found    : Boolean;

begin -- Insert_Entry

   Find_Entry (Name, Entry_Location, Entry_Found);
   -- "Insert is used to insert a new entry or to
   -- change the number of an existing entry
   if Entry_Found then

      Directory(Entry_Location).Telephone_Number := Telephone_Number;

   elsif Current_Database_Length   Directory'Last then
      Current_Database_Length := Current_Database_Length + 1;
      Directory (Current_Database_Length).Name := Name;
      Directory (Current_Database_Length).Telephone_Number := Telephone_Number;

   else
      raise Directory_Full;
   end_if;

end Insert_Entry;
```

INSTRUCTOR NOTES

SAME COMMENTS AS PREVIOUS SLIDE.

NOTE USE OF SLICE ASSIGNMENT (RATHER THAN A LOOP).

ALTERNATE (Continued)

```
separate (Directory_Services)

procedure Delete_Entry (Name : in Name_Type) is

   Entry_Location        : Index;
   Entry_Found           : Boolean;

begin -- Delete_Entry

   Find_Entry (Name, Entry_Location, Entry_Found);
   if Entry_Found then
      Directory (Entry_Location .. Current_Database_Length - 1) :=
         Directory (Entry_Location + 1 .. Current_Database_Length);
      Current_Database_Length := Current_Database_Length - 1;
   else
      raise Name_Not_In_Database;
   end if;

end Delete_Entry;
```

INSTRUCTOR NOTES

YOU CAN MENTION, OR EVEN DO, THE FOLLOWING EXERCISES:

1) CHANGE THE DATABASE REPRESENTATION. FOR EXAMPLE, KEEP THE LIST SORTED BY NAME, SO THAT LOOK-UP IS FASTER

2) ADD A COMMAND TO QUERY THE NAME GIVEN A PHONE NUMBER

3) ALLOW THE USER TO:

   -- READ A DIRECTORY FROM A FILE OF HIS OWN CHOICE

   -- SAVE THE DIRECTORY INTO A FILE OF HIS OWN CHOICE

   -- REINITIALIZE THE DIRECTORY IN MAIN MEMORY (PRESUMABLY TO START CREATING A NEW DIRECTORY)

   -- PRINT THE WHOLE DIRECTORY

THE IMPORTANT POINT IS THAT IT'S EASY TO SEE EXACTLY WHAT NEEDS TO BE CHANGED.

ALTERNATE (Continued)

```
separate (Directory_Manager.Get_Input_Request)

procedure Get_Name (Name : out Name_Type) is
   Last : Natural;

begin  -- Get_Name

   Put ("Please enter person's name (20 characters):");
   Get_Line (Name, Last);
   Name (Last+1 .. Name'Last) := (Last+1 .. Name'Last = ' ');
   if not End_Of_Line then
      Skip_Line;
   end if;

end Get_Name;

-------------------------------------------------------

separate (Directory_Manager.Get_Input_Request)

procedure Get_Number (Telephone_Number : out Telephone_Number_Type) is

   Last : Natural;

begin  -- Get_Number

   Put ("Please enter telephone number (4 digits):");
   Get_Line (Telephone_Number, Last);
   Telephone_Number (Last+1 .. Telephone_Number'Last) := (Last+1 .. Telephone_Number'Last =>' ');
   if not End_Of_Line then
      Skip_Line;
   end if;

end Get_Number;
```

INSTRUCTOR NOTES

THIS SECTION FORMALIZES MOST OF THE IDEAS AND CONCEPTS DISCUSSED AS A RESULT OF THE EXERCISE.

Section 18
CHARACTERISTICS OF GOOD ADA DESIGNS

ADA FOR SOFTWARE MANAGERS

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ADA FEATURES
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INTRODUCTION TO ADA DESIGN/CODE ASSESSMENT
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(SECTION 19)

INSTRUCTOR NOTES

FOR ANY PROGRAM, WHAT DO WE WANT TO SEE IN A DESIGN. USE THE EXERCISE TO GIVE EXAMPLE.

FOR EXAMPLE:

UNDERSTANDABILITY: MAIN PROCEDURE OF VSN 2 IS EASIER TO HAVE A TOP LEVEL VIEW OF THE SYSTEM WORKINGS.

RELIABILITY: WITH VSN 1 ON INCORRECT COMMAND WOULD CRASH THE SYSTEM.

QUALITIES OF A GOOD DESIGN

- MODIFIABILITY
  - THE REGION OF EFFECT FROM MODIFICATIONS IS KEPT TO A MINIMUM
- UNDERSTANDABILITY
  - THE EASE OF FUNCTIONAL UNDERSTANDING OF A SYSTEM AT THE TOP LEVEL
- RELIABILITY
  - THE ROBUSTNESS OR THE EASE WITH WHICH A SYSTEM RECOVERS OR PREVENTS SYSTEM FAILURES
- EFFICIENCY
  - PERFORMANCE ENGINEERED INTO A SYSTEM AFTER FUNCTIONS ESTABLISHED
- REUSABILITY
  - FUNCTIONS DESIGNED FOR THE USE OF SOFTWARE COMPONENTS

INSTRUCTOR NOTES

SOME GUIDELINES FOR A TECHNICAL MANAGER TO USE IN EVALUATING ADA DESIGN. THE LIST SUMMARIZES WHAT WILL BE NEXT DISCUSSED IN FURTHER DETAIL

NON-CENTRALIZED DATABASE = PACKAGING THE DATA SO IT IS KNOWN AND AVAILABLE ONLY WHERE NEEDED. THIS LIMITS THE USE OF GLOBAL DATA PREVALENT IN FORTRAN COMMON, JOVIAL COMPOOL.

CHARACTERISTICS OF GOOD ADA DESIGN

- QUALITIES OF A GOOD DESIGN (OF PREVIOUS SLIDE)
- READABLE
- DELIBERATE ABSTRACTION RATHER THAN VAGUENESS
- COMPLETE FUNCTIONAL DECOMPOSITION BEFORE PERFORMANCE
- NON-CENTRALIZED DATABASE ORGANIZATION
- SENSIBLE MODULARITY
- CONSERVATIVE USE OF LOW-LEVEL FEATURES
- CONSERVATIVE USE OF GOTO'S
- KNOWLEDGEABLE USE OF ADA CONSTRUCTS
- DESIGN STYLE IS NOT FORTRAN, PASCAL, ASSEMBLY LANGUAGE (NEW "MIND SET")

VERSION 2 OF THE EXERCISE READ MORE 'NATURALLY' AND REFLECTS WHAT WE CALL A CHANGE IN MIND SET (LOOK AT SYSTEM FROM USER'S VIEW RATHER THAN H/W).

READABLE

IN A GOOD ADA DESIGN

- CODE READS "NATURALLY" (I.E. CODE DIRECTLY REFLECTS THE REAL WORLD SOLUTION)
- WITH LITTLE EFFORT, THE SYSTEM STRUCTURE AND FUNCTIONS CAN BE UNDERSTOOD
- THE DESIGN REFLECTS THE SYSTEM USER'S VIEWPOINT, NOT THE HARDWARE CONSTRAINTS
- NAMES OF ENTITIES ACCURATELY REFLECT THEIR FUNCTION
- COMMENTS USED TO AUGMENT CODE NOT TO REPLACE POOR CHOICES OF NAMES AND LOGIC STRUCTURE

INSTRUCTOR NOTES

IN USING ABSTRACTION TO HIDE THE IMPLEMENTATION, WE DEFINE SAY A FUNCTION BUT NOT THE IMPLEMENTATION DETAILS. FOR EXAMPLE, Lookup_Entry, Find_Entry.

GOOD DESIGNERS USE THE EXPRESSION "I DON'T CARE HOW THIS IS IMPLEMENTED" TO MEAN "THERE ARE SEVERAL WORKABLE IMPLEMENTATIONS; I HAVE DEFINED THE INTERFACE SO THAT THE IMPLEMENTATION CHOICE CAN BE POSTPONED OR EVEN CHANGED LATER."

ABSTRACTION VS. VAGUENESS

IN A GOOD ADA DESIGN

- AN ABSTRACTION HIDES OR DEFERS IMPLEMENTATION POSSIBILITIES
- THE DESIGNER IS ABLE TO DESCRIBE IN SIMPLE ENGLISH THE INTENDED IMPLEMENTATION OR, BETTER, SEVERAL POSSIBLE IMPLEMENTATIONS
- THE INTERFACE IS USER-ORIENTED SO THE ABSTRACTION WILL BE EASY TO USE

IN A POOR ADA DESIGN

- THE ABSTRACTION IS USED TO HIDE A DESIGNER'S LACK OF THOROUGH PLANNING AND/OR A LACK OF UNDERSTANDING
- THE INTERFACE IS POORLY-PLANNED; A SIMPLE EXERCISE TO USE IT USUALLY REVEALS THAT THE ABSTRACTION IS INADEQUATE OR CLUMSY TO USE
- THE DESIGNER APPEARS TO BE GUESSING AT ONE IMPLEMENTATION WHEN ASKED TO DESCRIBE THE ABSTRACTION

INSTRUCTOR NOTES

POINTS OF GOOD ADA DESIGN VERY IMPORTANT. GENERALLY IN INDUSTRY PERFORMANCE IS CONSIDERED FIRST AND FOREMOST.

PERFORMANCE AND DESIGN

IN A GOOD ADA DESIGN

- THE FUNCTIONS ARE FIRMLY DEFINED FIRST. SYSTEM PERFORMANCE ESTIMATES AND DESIGN ADJUSTMENTS COME SECOND
- THE DESIGN DELIBERATELY ALLOWS FOR LATER TUNING

IN A POOR ADA DESIGN

- THE DESIGN IS CONCERNED PRIMARILY WITH PERFORMANCE (HOW CAN PERFORMANCE ESTIMATES BE ACCURATE IF THE FUNCTIONS ARE INCOMPLETELY DEFINED). IT IS VERY EASY TO SEE THAT THE SOFTWARE MEETS ITS PERFORMANCE CONSTRAINTS, BUT TOO HARD TO FIGURE OUT WHAT IT DOES.
- PERFORMANCE IS NOT CONSIDERED AT ALL

INSTRUCTOR NOTES

POOR ADA DESIGN - SOME EXAMPLES.

FORTRAN'S "COMMON"

JOVIAL'S "COMPOOL"

NOT USING GLOBAL DATA IS A NEW CONCEPT AND TAKES TRAININC AND KNOWLEDGEABLE MANAGERS AND QA TO MONITOR.

ESSENTIALLY, STUFF USED AS GLOBAL BEFORE SHOULD NOW BE PASSED AS PARAMETERS.

DATABASE ORGANIZATION

IN A GOOD ADA DESIGN

- THERE IS NO NEED TO USE GLOBAL DATA IN ADA
  - DATA SHOULD BE DECLARED WHERE IT IS USED
  - AS A RESULT, LESS "HUNTING" FOR AN OBJECTS DECLARATION REQUIRED

- GLOBAL DATA SHOULD BE THE EXCEPTION NOT THE RULE
  - THIS STYLE REQUIRES MUCH MORE DESIGN AND PLANNING
  - NATURAL RESISTANCE SINCE PEOPLE DON'T LIKE TO PLAN AND WOULD RATHER START PROGRAMMING

IN A POOR ADA DESIGN

- LARGE QUANTITIES OF DATA COLLECTED INTO SINGLE PROGRAM UNITS

INSTRUCTOR NOTES

BY MODULARITY WHEN THE STRUCTURING OF THE SYSTEM HAS A DEFINITE PURPOSE IN MIND.

THIS IS WHERE THE LIFE-CYCLE COST BENEFITS CAN COME. BY APPROPRIATE GROUPING, THE EFFECT OF MODIFICATIONS IS LOCALIZED. FOR EXAMPLE, IN VERSION 2, Directory_Manager ONLY MANAGES THE DIRECTORY SYSTEM IT DOESN'T INTERFACE WITH THE USES FOR INPUT REQUESTS OR DATA.

MODULARITY

IN A GOOD ADA DESIGN

- RELATED OBJECTS AND OPERATIONS ARE GROUPED TOGETHER
- THERE EXISTS A LOGICAL, SENSIBLE ORDER TO MODULARITY OF THE SYSTEM

IN A POOR ADA DESIGN

- HAPHAZARD OR UNCLEAR RELATIONSHIP OF ENTITIES IN A MODULE
- MODULARITY BASED ON PHYSICAL OR PERFORMANCE CONSIDERATIONS

INSTRUCTOR NOTES

IMPORTANT TO NOTE LOW-LEVEL FEATURES SHOULD BE USED FOR EXTERNAL HARDWARE INTERFACE ONLY <u>NOT</u> TO INCREASE EFFICIENCY. FOR DESIGNERS OR PROGRAMMERS WITH ASSEMBLY LANGUAGE BACKGROUNDS, IT COULD BE ESPECIALLY TEMPTING TO USE THESE FEATURES AS THEY WILL FEEL MORE COMFORTABLE WITH THEM THAN WITH THE HIGH ORDER LANGUAGE FEATURES.

LOW-LEVEL FEATURES

IN A GOOD ADA DESIGN

- USED SPARINGLY
- USED TO INTERFACE WITH THE EXTERNAL HARDWARE

IN A POOR ADA DESIGN

- USED FREQUENTLY
- USED TO INCREASE PERFORMANCE (RATHER THAN FIND A BETTER DESIGN SOLUTION)
- USED TO CIRCUMVENT A PURPORTED DEFICIENCY OF THE LANGUAGE. USUALLY A SIGN THAT THE PROGRAMMER/DESIGNER IS THINKING IN SOME OTHER LANGUAGE.

INSTRUCTOR NOTES

GOTO'S

IN A GOOD ADA DESIGN

- SPARINGLY USED
- POSSIBLE USE IS IN FINITE STATE MACHINES (GOTO NEXT STATE)

IN A POOR ADA DESIGN

- USED INSTEAD OF STRUCTURED PROGRAMMING CONSTRUCTS, EXCEPTIONS, EXITS

INSTRUCTOR NOTES

USE OF ADA FEATURES IS A PLANNED ACTIVITY.

EACH ADA FEATURE IS IN THE LANGUAGE FOR SPECIFIC REASONS AND SHOULD BE USED ACCORDINGLY. FOR EXAMPLE:

COMMON ALGORITHM, DIFFERENT DATA => GENERICS

INFORMATION HIDING => SPECIFICATION/BODY OF PROGRAM UNITS

"KNOWLEDGEABLE" USE OF ADA FEATURES

IN A GOOD ADA DESIGN

- USED WITH DELIBERATE INTENT

  FOR EXAMPLE:

  - TO INCREASE MODULARITY
  - TO INCREASE READABILITY

IN A POOR ADA DESIGN

- USED BECAUSE THE CONSTRUCT WAS "HANDY"

  FOR EXAMPLE:

  - PRIVATE TYPES USED TO AVOID CAREFUL PLANNING OF OBJECT ACCESS NEEDS
  - LOW-LEVEL FEATURES USED BECAUSE OF GREATER FAMILIARITY
  - GOTO'S AND EXCEPTIONS USED TO AVOID STRUCTURED PROGRAMMING LOGIC

INSTRUCTOR NOTES

POSSIBLY BEFORE PRESENTING THE EXAMPLE OF ARRAYS, QUICKLY REFER BACK TO THE DIRECTORY SYSTEM. THE FIRST VERSION IS BASICALLY FORTRAN OR PASCAL THINKING IN ADA SYNTAX.

"MIND SET" CHANGE

ADA HAS FEATURES OR CONSTRUCTS THAT ALLOW US TO SOLVE PROBLEMS IN A NEW, MORE "NATURAL", STYLE. OUR DESIGN AND CODE CAN MORE ACCURATELY MATCH THE REAL WORLD. TO EFFECTIVELY USE THE POWER OF ADA, THIS CHANGE OF PERSPECTIVE MAY BE NECESSARY.

IN A POOR ADA DESIGN

- THE CONSTRUCTS AND METHODS USED IN DESIGNING FOR FORTRAN, PASCAL, JOVIAL, OR ASSEMBLY LANGUAGE APPEAR IN ADA SYNTAX

FOR EXAMPLE:

NON-ADA STYLE	ADA STYLE
-- MULTIDIMENSIONAL ARRAY	-- ARRAY OF ARRAYS
-- CRYPTIC IDENTIFIERS	-- EXPANDED IDENTIFIERS
-- LITTLE USE OF ATTRIBUTES	-- ATTRIBUTES USED
-- RECODE ALGORITHM FOR EACH TYPE OF DATA	-- GENERICS

INSTRUCTOR NOTES

WE CAN SHOW WAYS TO USE FEATURES, GIVE SOME DESIGN CHARACTERISTIC GUIDELINES, BUT THE MANAGER NEEDS TO TEMPER THESE WITH HIS/HER OWN GUT FEELINGS.

MANAGER'S GENERAL ADA GUIDE

DON'T COUNT OCCURRENCES OF (OR LACK OF) GOOD ADA DESIGN FEATURES, RATHER ASK:

- "IS THE DESIGN OR CODE EASY TO UNDERSTAND?"
- "IS IT EASY TO GET AN OVERALL 'BIG PICTURE'?"
- "DOES IT FEEL NATURAL?"
- "DOES IT SPEAK THE USER'S LANGUAGE?"
- "DOES IT MAKE SENSE?"

ASK DESIGNERS OR PROGRAMMERS TO EXPLAIN WHY THEY USED OR DID NOT USE A PARTICULAR ADA CONSTRUCT OR DESIGN FEATURE

INSTRUCTOR NOTES

ONE OF ADA'A PRIMARY GOALS AS A LANGUAGE WAS TO INCREASE THE REUSABILITY AND PORTABILITY OF SYSTEMS OR PARTS TO PRODUCE A SOFTWARE COMPONENTS INDUSTRY (SIMILAR TO H/W COMPONENTS). THIS SECTION PROVIDES SOME GUIDELINES AND A GRASP OF THE ISSUES INVOLVED. THIS SECTION THUS SUMMARIZES THE ENTIRE COURSE.

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INSTRUCTOR NOTES

REUSABILITY

- IMPLIES THAT A SECTION OF SOFTWARE DEVELOPED FOR ONE APPLICATION CAN BE REUSED FOR ANOTHER APPLICATION
- APPLIES WITHIN A PROJECT AND ACROSS PROJECTS
- WILL NOT HAPPEN BY CHANCE
  - REQUIRES ADVANCE PLANNING, DESIGN, AND EXPERIENCE
  - REQUIRES CHANGE IN VIEWING OF PROBLEM SOLUTIONS AS COMBINATIONS OF SOFTWARE COMPONENT OR CONSTRUCTS LIKE HARDWARE CHIPS

INSTRUCTOR NOTES

CANDIDATES FOR REUSABLE COMPONENTS

GENERAL PURPOSE ALGORITHMS OR DATA CONSTRUCTS

FOR EXAMPLE:

- MAN/MACHINE INTERFACES
- DEVICE DRIVERS
- SORT ROUTINES
- SEARCH ROUTINES
- STACKS AND QUEUES
- TABLES

INSTRUCTOR NOTES

ADA FEATURES AND REUSABILITY

- PACKAGES TO ENCAPSULATE THE SOFTWARE COMPONENT
- LIBRARY UNITS TO BUILD A DESIGNER'S "TOOL KIT"
- GENERICS WERE SPECIFICALLY DESIGNED TO AID IN THE PRODUCTION OF REUSABLE SOFTWARE COMPONENTS
- USE OF ATTRIBUTES CAN INCREASE REUSABILITY

CONTEXT:

```
      N : Integer;
      type Arr_Type is array (1 .. N) of Integer;
      V : Arr_Type;
```

EXAMPLE:

```
      for Index in V'Range ... RATHER THAN
      for Index in 1 .. 60 ... WHERE V CONSTRAINED TO VALUES 1 .. 60
                               IN ONE APPLICATION, BUT 1 .. 35 IN ANOTHER
```

INSTRUCTOR NOTES

PORTABILITY

IMPLIES A SECTION OF SOFTWARE DEVELOPED ON ONE COMPUTER SYSTEM CAN BE RUN ON ANY OTHER SYSTEM WITH THE SOFTWARE FUNCTIONING IN THE SAME WAY AS ON THE ORIGINAL SYSTEM.

THE AMOUNT OF MODIFICATION TO THE ORIGINAL CODE NECESSARY TO ACCOMPLISH THIS SAMENESS OF FUNCTION IS THE DEGREE OF PORTABILITY.

PERFECT PORTABILITY (NO CHANGES REQUIRED) IS SELDOM ACHIEVABLE. REALISTICALLY, A PROGRAM IS CONSIDERED PORTABLE IF:

- THE PARTS THAT WILL NEED CHANGES ARE PRE-IDENTIFIED (NO SURPRISES)
- NO REDESIGN IS REQUIRED (ONLY RE-CODING)
- THE AMOUNT OF RE-CODING IS NEGLIGIBLE COMPARED TO THE TOTAL IMPLEMENTATION EFFORT

INSTRUCTOR NOTES

TECHNICAL MANAGERS SHOULD BE AWARE OF THIS.

IMPORTANCE OF PORTABILITY

RELIABILITY

- EMBEDDED COMPUTER SYSTEMS GENERALLY DEVELOPED ON A HOST COMPUTER BUT THE EVENTUAL TARGET COMPUTER IS DIFFERENT THAN THE HOST
- PROGRAM NEEDS TO PERFORM THE SAME WHETHER RUN ON THE HOST OR TARGET SYSTEMS

DECREASE IN SOFTWARE COSTS

- HARDWARE TECHNOLOGICAL DEVELOPMENT IS INCREASING AS WELL AS SOFTWARE COSTS
- AS TARGET MACHINES ARE UPGRADED, SOFTWARE THAT HAS BEEN DEVELOPED FOR PORTABILITY CAN BE REUSED

INSTRUCTOR NOTES

THIS IS TO PROVIDE THE STUDENT WITH A FEEL FOR THE SCOPE OF THE ISSUES INVOLVED. NOT ALL ISSUFS ARE PRESENTED AS IT IS FELT THIS SHOULD BE LEFT TO EXPERTS TO ADVISE IN THIS AREA. THE MANAGER NEEDS TO KNOW ENOUGH OF THE ISSUES TO BE ABLE TO ASK AND SEE IF DESIGNERS ARE PLANNING WITH PORTABILITY IN MIND.

SOME CHARACTERISTICS OF PORTABLE SOFTWARE

- DESIGN AND CODE ARE STRAIGHTFORWARD AND EASY TO UNDERSTAND

- DOCUMENTATION STATES THE IMPLEMENTATION CHARACTERISTICS REQUIRED OF THE PROGRAM AND THE PARTICULAR PORTABILITY CHARACTERISTICS OF EACH PROGRAM UNIT

- LOGICALLY RELATED OBJECTS ARE PHYSICALLY GROUPED TOGETHER TO LOCALIZE THE EFFECT OF CHANGES

- PACKAGES USED TO ENCAPSULATE EXPECTED AREAS OF MODIFICATION, THUS ONLY THE PACKAGE BODY NEEDS REWRITTING BUT NONE OF THE PROGRAM UNITS USING THE PACKAGE

INSTRUCTOR NOTES

CHARACTERISTICS (Continued)

CONSERVATIVE USE OF IMPLEMENTATION DEPENDENT FEATURES, FOR EXAMPLE:

- PRAGMAS (COMPILER DIRECTIVES)
- ATTRIBUTES FIRST AND LAST
- THE PREDEFINED EXCEPTIONS Numeric_Error, Constraint_Error

INSTRUCTOR NOTES

CHARACTERISTICS (Continued)

REPRESENTATION SPECIFICATIONS AND MACHINE CODE ARE LOCALIZED IN PACKAGES

RESTRICTED USE OF Low_Level_IO. IF NEEDED, ENCAPSULATE IN PACKAGES

SYSTEM PERFORMANCE (EITHER SPACE OR TIME) IS NOT DEPENDENT ON MACHINE OR RUN-TIME SPECIFIC OPTIMIZATIONS

INSTRUCTOR NOTES

IN CONCLUSION

- REUSABILITY AND PORTABILITY REQUIRES CAREFUL PLANNING IN DESIGN
- REUSABILITY AND PORTABILITY CONCERNS ARE COMPLEX, TRADE-OFFS MAY BE NECESSARY
- DEGREE OF PORTABILITY IS HARD TO ASSESS BY INSPECTION OR BY EXPERIMENT. EXPLICIT TRAINING IS NECESSARY

INSTRUCTOR NOTES

SIMPLICITY OF DESIGN AND CODE IS THE KEY TO MANAGING THE COMPLEXITY OF SYSTEMS.

A FINAL NOTE ...

THE KEY TO COMPLEXITY

IS

SIMPLICITY

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TRADEMARK) FOR SOFTWARE MANAGERS L201 TEACHER'S GUIDE
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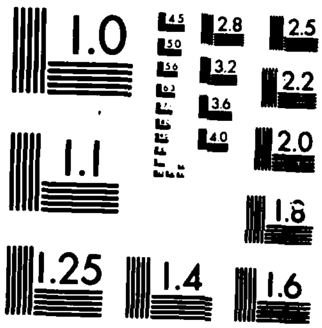

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Yes □ No □

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If yes, on what pages?

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COMMANDER
US ARMY MATERIEL COMMAND
ATTN: AMCDE-SB (OGLESBY)
5001 EISENHOWER AVENUE
ALEXANDRIA, VIRGINIA 22233

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